B.E.Eighth Semester (Civil Engineering) (C.B.S.)

Elective - II : Pavement Analysis & Design

P. Pages : 5 **NKT/KS/17/7532**

Time : Three Hours * 0 7 2 7 * Max. Marks : 80

Notes :
1. All questions carry marks as indicated.
2. Solve Question 1 OR Questions No. 2.
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5. Solve Question 7 OR Questions No. 8.
6. Solve Question 9 OR Questions No. 10.
7. Solve Question 11 OR Questions No. 12.
8. Due credit will be given to neatness and adequate dimensions.
9. Assume suitable data whenever necessary.
10. Illustrate your answers whenever necessary with the help of neat sketches.
11. Use of non programmable calculator is permitted.

1. a) Discuss the various stress influencing factors in Flexible and Rigid pavement. **6**

b) What is ESWL ? Estimate the ESWL for dual-in-tandem wheel assembly for an aircraft. **7**
Data :
i) Gear load = 35000 kg
ii) Tyre pressure = 10.5 kg/cm^2
iii) Tandem spacing = 250 mm
iv) Dual spacing = 180 mm
v) Flexible crust thickness = 65 cm, 80 cm, 115 cm

OR

2. a) Explain the concept of ESWL and explain the assumptions on which it is based. **4**

b) Clearly distinguish between Airfield and Highway pavement. **4**

c) Calculate total fatigue from given traffic data with 15 year life ad 2 years construction period with growth rate of 6%. **5**

Axle load Kg	1150	2050	4000	6150	8100	10150	12100
Avg. Daily traffic ADT	130	85	110	150	160	85	60

3. a) Explain in detail Marshall's method of Bituminous Mix Design. **6**

b) Soil subgrade sample collected from the site was analysed and the result obtained are as given below. Design the pavement section by Group Index method for the anticipated traffic volume of over 300 CVD. **7**
i) Passing 425 micron 82%
ii) Passing 75 micron 65%
iii) Liquid limit 53%
iv) Plastic limit 28%

OR

4. a) Explain plate load test for evaluating modulus of subgrade reaction and corrections to be applied. **7**

b) Calculate the cone bearing value from following data of North Dakota Cone test. Half angle of cone is 7°45' : **6**

Load (kg)	Penetration (mm)
4.5	22.3
9.0	35.1
18.0	53.4
36.0	72.5

5. a) What is difference between AASHTO & IRC methods of classification of bitumen ? **6**

b) The following observations were noted in a laboratory CBR tests conducted on subgrade soil. Calculate CBR of the soil and hence design the pavement. **8**

Penetration (mm)	Load (kg)
0.0	0
0.5	9
1.0	34
1.5	69
2.0	91
2.5	106
3.0	131
4.0	154
5.0	176
7.5	200
10.0	230
12.5	240

It is further proposed to use the following material for different.
Pavement layers :
Compacted soil with 8% CBR
Poorly graded gravel with 25% CBR
Well graded gravel with 85% CBR
The traffic survey revealed the present ADT of commercial vehicle as 1400. The annual rate of growth of traffic is found to be 7.5%, the pavement construction is to be completed in three years after the best traffic count. Design the pavement section using CBR method as recommended by IRC, assuming 15 years service life. (Use CBR design chart)

OR

6. a) What is the objective of Triaxial Compression test ? Explain the test in detail. **6**

b) Determine the required thickness of an airfield flexible pavement based on Burmister's Theory using the following plate load test data and other input parameters : **8**

- Diameter of plate used = 75 cm
- Pressure observed at 1.25 mm deflection when the plate load test is conducted on the sub-grade = 0.82 kg/cm^2
- Pressure observed at 1.25 mm deflection when the plate load test is conducted on a base course of 16 cm thickness = 2.1 kg/cm^2
- Design wheel load = 23000 kg
- Tyre pressure = 15 kg/cm^2

(i) If allowable deflection = 0.125 cm and (ii) If allowable deflection = 0.50 cm

7. a) Write in detail about different kinds of stresses in rigid pavements. **6**

b) For the above pavement calculate safe spacing of contraction and expansion joints and design a longitudinal Tie-bar joint from following data : **7**

i) Permissible shrinkage stress in C. C. = 0.85 kg/cm^2
ii) Width of Expansion joint = 25 mm
iii) Seasonal Temperature variation m = 45°C
iv) Permissible tensile stress inn Tie-bar = 2000 kg/cm^2
v) Bond stress in steel = 25 kg/cm^2
vi) Lane width = 3.0 m.

OR

8. a) Explain LCN method of Airfield pavement design. **6**

b) Explain PCA method of rigid pavement design in detail. **7**

9. a) State the need & scope of plate load test. What are the standard specifications of the test. **6**

b) Benkelman Beam Deflection studies were carried out on 15 points using a dual wheel load of 4085 kg & 5.6 kg/cm^2 pressure. If the traffic consist of 750 CVD, determine the thickness of bituminous overlay required, if the pavement temperature during the test was 30°C and moisture content is 1.3. Assume annual rate of growth of traffic as 7.5% Adopt IRC guideline. Deflection values in mm are given bellows. **7**
1.4, 1.32, 1.25, 1.35, 1.48, 1.6, 1.65, 1.55, 1.45, 1.4, 1.36, 1.46, 1.5, 1.52, 1.45.

OR

10. a) Define the following terms : **4**
i) Field Density ii) Profilometer

b) Design a rigid pavement for a two lane highway from the given data : **9**
Design wheel load = 5100 kg
Radius of contact area = 15 cm
Grade of concrete = M30
Modulus of subgrade reaction = 8 kg/cm^2
Cx = 0.92
Cy = 0.72
Temperature Gradient = 0.6°C/cm
Assume any other required suitable data.

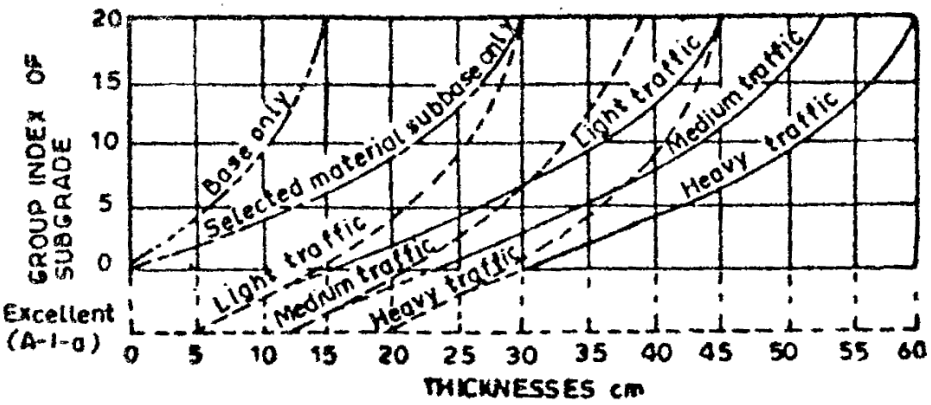
11. Check the adequacy of rigid pavement from IRC criteria : **14**
i) Slab thickness 150 mm
ii) 'E' of concrete 3 x 10^5 kg/cm^2
iii) Poissons ratio of concrete 0.15
iv) Thermal expansion coefficient 10 x 10^{-6}/°C
v) M.O.R. of concrete 48 kg/cm^2
vi) Anticipated thermal gradient across slab 0.5°C/cm
vii) 'K' of subgrade soil 6.5 kg/cm^2/cm
viii) Cx & Cy 0.82 & 0.45 resp.
ix) Wheel load 3000 kg
x) Tyre pressure 4.5 kg/cm^2

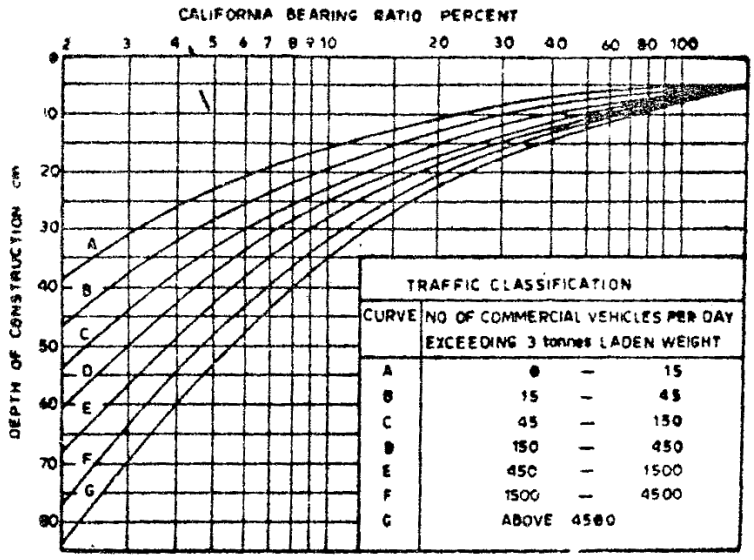
OR

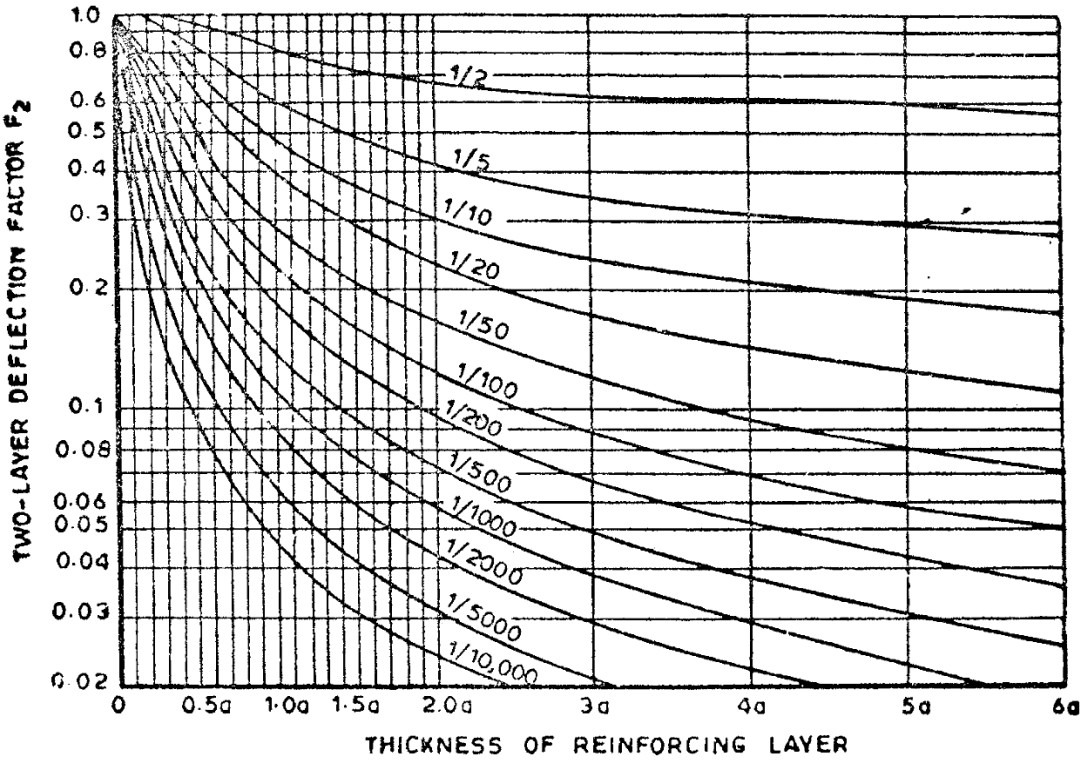
12. a) Explain the various methods used for the maintenance and rehabilitation of flexible and Rigid pavements. **7**

b) Design a dowel bar system for the following data : **7**

i) Pavement thickness = 200 mm
ii) Radius of relative stiffness = 55 cm
iii) Width of relative expansion joint gap = 20 mm
iv) Permissible shear stress in dowel bar (F_s) = 1000 kg/cm^2
v) Permissible flexural stress in dowel bar (F_f) = 1400 kg/cm^2
vi) Bearing stress in concrete (F_b) = 100 kg/cm^2
vii) Wheel load = 4000 kg






TWO-LAYER DEFLECTION FACTOR F_2
1.0
0.8
0.6
0.5
0.4
0.3
0.2
0.1
0.08
0.06
0.05
0.04
0.03
0.02
1/2
1/5
1/10
1/20
1/50
1/100
1/200
1/500
1/1000
1/2000
1/5000
1/10,000
0
0.5a
1.0a
1.5a
2.0a
3a
4a
5a
6a
THICKNESS OF REINFORCING LAYER

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B.E. (Civil Engineering) Eighth Semester (C.B.S.)

Elective-II : Pavement Analysis & Design

P. Pages : 3 **NRJ/KW/17/4670**

Time : Three Hours * 0 2 3 4 * Max. Marks : 80

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9. Assume suitable data whenever necessary.
10. Diagrams and chemical equations should be given whenever necessary.
11. Illustrate your answers whenever necessary with the help of neat sketches.
12. Use of non programmable calculator is permitted.

1. a) Clearly distinguish between Highway and Airfield Pavements. **6**

b) Discuss the effects of repeated application of loads on pavement. Explain equivalent wheel load factors for load repetitions. **7**

OR

2. a) With neat sketches enumerate the function and importance of each component layer both in flexible and rigid pavements. **6**

b) Estimate the ESWL for dual - in tendon wheel assembly for an aircraft Data : **7**
- i) Gear Load = 26800 kg
- ii) Tyre Pressure = $10.6\,kg/cm^2$
- iii) Dual spacing = 225 mm clear
- iv) Tendon spacing = 350 mm clear
- v) Flexible crust thickness = 550, 750, 900 mm

3. a) Estimate the group index of subgrade soil from following data and discuss the rating as subgrade. **7**
- i) Passing 425 micron = 75%
- ii) Passing 75 micron = 60%
- iii) Liquid limit = 51%
- iv) Plastic limit = 28%

b) Calculate the cone bearing value from the following data of North Dakota cone test (Half Angle of cone = $7^o\ 45'$) **7**

Load (kg)	Cone penetration (mm)
4.5	2.91
9.0	4.09
18.0	5.96
36.0	8.35

OR

4. The following results were noted in a laboratory CBR tests conducted on subgrade soil : **14**

Penetration (mm)	0	0.5	1.0	1.5	2.0	3.0	4	5	7	7.5	10	12.5
Load (kg)	0	6	18	32	50	60	65	75	80	90	95	100

It is desired to use the following materials for different pavement layers :

i) Compacted soil subgrade having CBR = 10%

ii) Poorly graded gravels having CBR = 22%

iii) Well graded gravels having CBR = 90%

The traffic survey indicates present ADT of commercial vehicle as 1400 with construction period of 2 years. The design life is 10 years with the expected traffic growth rate of 10%. Suggest the suitable crust composition with neat sketch.

5. a) Explain AASHTO method of flexible pavement design. **5**

b) The pressure for 5 mm deformation in both tests was recorded as $2.5\,kg/cm^2$ and $4.7\,kg/cm^2$ resp. for flexible pavement of 30 cm base course, find the pavement deformation, vertical and radial stress, stress at the subgrade under the load of 6100 kg acting at a tyre pressure of $6.2\,kg/cm^2$. Assume, Poisson's ratio of subgrade as (0.38). A plate load test was conducted on subgrade and also on 20 cm thick base with 30 cm diameter plate. **9**

OR

6. Design a flexible pavement for design traffic volume of 3770 CVD, if the permissible deflection of 0.5 cm by Triaxial method. Data Given : **14**

i) Wheel load = 6200 kg.

ii) Tyre pressure = $6.6\,kg/cm^2$

iii) Annual Rainfall = 92 cm.

iv) Modulus of elasticity of: subgrade = $80\,kg/cm^2$

Sub base = $415\,kg/cm^2$, Base = $1950\,kg/cm^2$

v) Bituminous surfacing = $4400\,kg/cm^2$

vi) Traffic coefficient = 8/6

vii) Rainfall coefficient = 0.9

7. a) Explain P.C.A. method of design of rigid pavement with neat sketches of charts. **6**

b) Write short note on LCN method of Airfield pavement design. **7**

OR

8. Estimate the load factor at all the regions of runway concrete pavement of 275 mm thickness under ESWL = 26,000 kg at $10.5\,kg/cm^2$ tyre pressure. Assume grade of concrete M : 300 and K for subgrade soil = $8.0\,kg/cm^3$. Also locate the position of failure and draw failure pattern. **13**

9. a) Design a pavement in M : 300 concrete for 2 lane highway expected to carry projected traffic of 1870 CVD of ESWL = 5100 kg at $6.8\,kg/cm^2$ tyre pressure from following data: **9**

i) K for subgrade = $5.7\,kg/cm^2/cm$
ii) E for concrete = $3.1\times10^4\,kg/cm^2$
iii) Poisson's ratio of concrete = 0.18
iv) Contraction joint spacing = 5.25 m
v) Temperature gradient = $0.95^oC/cm$
vi) Subgrade Restraint Coefficient = 1.35
vii) Temperature coefficient :

Lx; y	4	5	6	7	8	9	10	11	12 & more
Cx, y	0.44	0.72	0.92	1.03	1.07	1.08	1.07	1.05	1.02

b) Explain in detail design of expansion joint and longitudinal tie bar joint for rigid pavement. **4**

OR

10. a) Design a bituminous overlay for a pavement section 3 km long the Benkelman Beam test is conducted at a rate of one test for 250 m length over a two section. The following valves of deflection are recorded 1.38, 1.52, 1.67, 1.31, 1.7, 1.92, 1.68, 1.2, 1.84, 1.93, 1.46, 1.55 mm. The test temp, of pavement is 26ºC. Present traffic volume is 750 CVD. Assume growth rate of 9.5% per year for service life of 10 years with delay of 1 year. **6**

b) A plate load test with 30 cm dia plate conducted a subgrade give following data : **7**

Deformation (mm)	0.25	0.5	0.75	1.0	1.25	1.50	1.75	2.0
Load on plate (kg)	200	480	730	1005	1240	1475	1720	1975

Estimate the modulus of Subgrade Reaction.

11. Design a rigid pavement for 2 - lane highway from following data : **13**

i) Design wheel load = 5100 kg
ii) Tyre pressure = $6.2\,kg/cm^2$
iii) Modulus of subgrade reaction = $7.5\,kg/cm^2$
iv) Grade of concrete = M 250
v) Temp gradient = $0.6^oC/cm$
vi) Panel dimensions = $3.0\,m\times6.0\,m$
vii) Initial traffic volume = 860 CVD
viii) Design Life = 20 years.

OR

12. Check the Adequacy of rigid pavement from IRC criteria.

i) Slab thickness 150 mm
ii) 'E' for concrete = $3\times10^5\,kg/cm^2$
iii) Poisson's ratio of concrete 0.15
iv) Thermal Expansion coeff. $10\times10^{-6}/^oC$
v) MOR of concrete $48\,kg/cm^2$
vi) Anticipated thermal Gradient across slab $0.5^oC/cm.$
vii) 'K' for subgrade soil $6.5\,kg/cm^2/cm$
viii) Cx and Cy 0.82 and 0.45 respectively.
ix) Wheel load (ESWL) 5100 kg.
x) Tyre pressure = $6.0\,kg/cm^2$

Assume any other data suitable if necessary.

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B.E. Eighth Semester (Civil Engineering) (C.B.S.)

Elective - II : Pavement Analysis & Design

P. Pages : 4 **KNT/KW/16/7532**

Time : Three Hours * 0 3 1 9 * Max. Marks : 80

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11. Illustrate your answers whenever necessary with the help of neat sketches.
12. Use of non programmable calculator is permitted.

1. a) Cleary distinguish between Highway and Airfield pavements. **6**

b) Estimate the ESWL for Dual-in-tandem wheel assembly for an aircraft with the following data : **7**
Gear load 30000 kg
Tyre pressure 9.8 kg/cm^2
Dual spacing 300 mm clear
Tandem spacing 450 mm clear
Crust thickness 500, 750 and 800 mm

OR

2. a) Compare flexible and rigid pavements. **6**

b) Estimate total fatigue in a service life of 15 years in terms of standard axle load of 8100 kg. Assume growth rate of traffic as 7.5 percent per annum and delay in opening to traffic of 2 years. **7**

Axle load Group	Present ADT	Eg. load factor
<1000 kg	160	0.0025
1 - 3 t	220	0.03
3 - 5 t	170	0.35
5 - 7 t	158	0.60
7 - 9 t	189	1.00
9 - 11 t	108	2.32
11 - 13 t	82	4.52
13 - 15 t	68	7.60
> 15 t	07	12.80

3. a) Estimate the group index of subgrade soil from following data and discuss its rating as subgrade : **7**

i) Passing 425 micron 73%
ii) Passing 75 micron 58%
iii) Liquid Limit 54%
iv) Plastic Limit 26%

b) Calculate cone bearing value for following data : **7**

Load (kg)	Cone penetration (mm)
4.5	21.9
9.0	32.7
18.0	51.3
36.0	71.6

Assume that the half angle of cone is 7º45'.

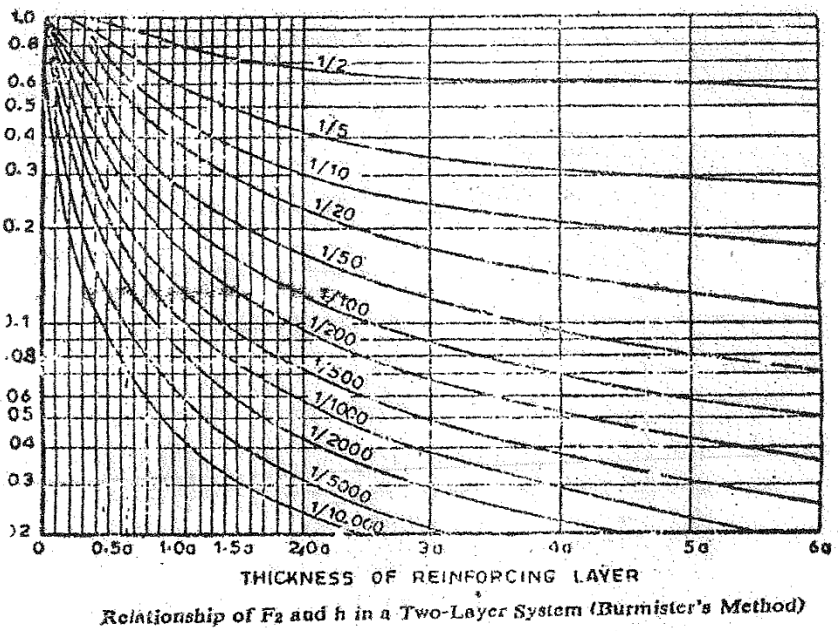
OR

4. a) Estimate the vertical compressive stress at depth = 24 cm and surface deflection for a subgrade with the following data **7**

i) Wheel load = 3200 kg at 4.5 kg/cm^2 T.P.
ii) E of subgrade = 250 kg/cm^2.
iii) Poisson's Ratio = 0.47

b) A flexible pavement is to be constructed over subgrade CBR of 5%. Estimate total crust thickness if maximum wheel load is 8000 kg at T.P. = 6.5 kg/cm^2. **7**

5. a) A plate load test conducted with 30 cm dia. plate on subgrade and also on 20 cm thick base recorded a load of 1800 kg and 5400 kg respectively for 2.5 mm deformation. Design the pavement section for a wheel load of 5200 kg at 5.1 kg/cm^2 tyre pressure for allowable deformation of 3.5 mm. Assume Poisson's ratio of subgrade = 0.48. **7**



Relationship of F_2 and h in a Two-Layer System (Burmister's Method)

Fig. Q No. 5(a)

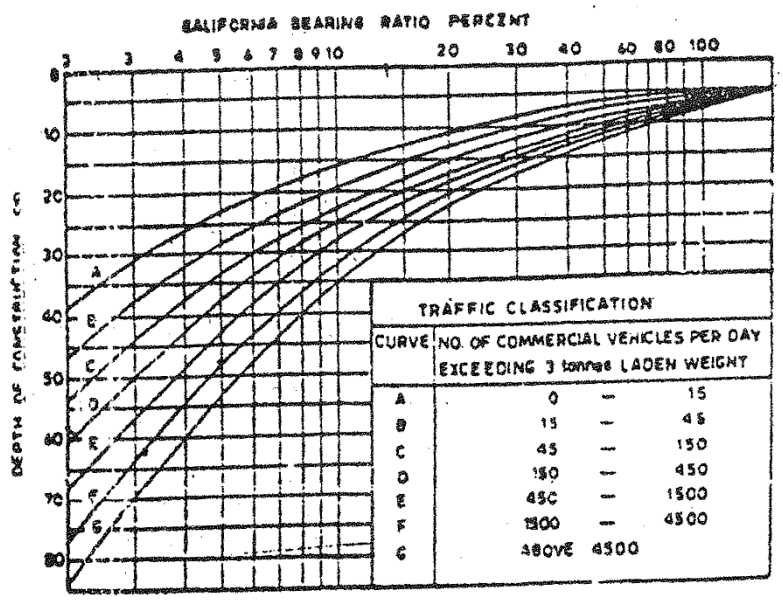
b) The CBR test carried out on a subgrade soil gave following readings. **7**

Penetration (mm)	Load (kg)	Penetration (mm)	Load (Kg)
0.0	0.0	4.0	74.0
0.5	5.0	5.0	75.5
1.0	12.0	7.5	92.3
1.5	32.0	10.0	103.4
2.0	43.0	12.5	112.6
2.5	48.0		
3.0	56.0		

The different pavement materials available near the construction site are as follows.

i) Sandy soil of CBR = 12%
ii) Soil - Kankar mix of CBR = 20%
iii) Crusted Gravel of CBR = 80%

Design a flexible pavement if initial traffic is 300 CVD, traffic growth rate is 7.5% and design life of pavement 20 yrs. Minimum bituminous surfacing be 5 cm.



C.B.R. Design Chart (Recommended by IRC)

Fig. Q No 5(b)

OR

6. a) Design a flexible highway pavement if maximum surface deflection is not to exceed 1.5 mm from following data : **7**

i) Wheel load - 4000 kg at T. P. = 5.5 kg/cm^2
ii) 'E' of surface - 2000 kg/cm^2
iii) 'E' of base course - 1000 kg/cm^2
iv) 'E' of sub base - 4000 kg/cm^2
v) 'E' of subgrade - 100 kg/cm^2
vi) Traffic coefficient - 1.6
vii) Saturation coefficient - 0.80

b) Explain LCN method of Air field pavement design. **7**

7. Design a Rigid pavement for a two lane highway from the given data : **13**

i) Wheel load 5100 kg
ii) Tyre pressure 5.7 kg/cm^2
iii) Grade of concrete M30
iv) Modulus of subgrade reaction 7.2 $kg/cm^2/cm$
v) $C_X = 0.8$, $C_Y = 0.7$
vi) Temperature gradient 0.52 ºC/cm
vii) Projected traffic volume 2500 CVD.

OR

8. a) Estimate the load factor at all regions of runway concrete pavement of 300 mm thickness under ESWL = 12000 kg at 8.5 kg/cm^2 tyre pressure. Assume grade of concrete M30 and 'K' for subgrade soil = 7.5 $kg/cm^2/cm$. **7**

b) Explain in detail AASHO method of Rigid pavement design. **6**

9. a) Explain plate load test for evaluation of modulus of subgrade reaction and correction to be applied. **7**

b) Explain the following. **6**
i) Serviceability Index.
ii) Profilometers.

OR

10. a) Explain Benkelman Beam Test in detail. **7**

b) Explain Marshall's method of Bituminous mix Design. **6**

11. a) Following observation were recorded in a Benkalman Beam deflection investigation for certain section of a state highway 1.42, 1.34, 1.28, 1.30, 1.61, 1.58, 1.54, 0.96, 1.44, 1.36, 1.54, 1.45mm (corrected values). Design a bituminous overlay if maximum allowable deflection is 0.80 mm. Assume layer equivalency factor. **7**

b) Explain maintenance & Rehabilitation of pavements. **6**

OR

12. a) Explain strengthening of Existing pavements and design of overlap. **7**

b) What are IRC specification for the highway pavements. **6**

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