GATE – CIVIL ENGINEERING

TRANSPORTATION ENGINEERING

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Prof.B.Jayarami Reddy
Professor and Head
Department of Civil Engineering
Y.S.R. Engineering College of
Yogi Vemana University,
Proddatur, Y.S.R.(Dt.), A.P-516360.
E.mail : bjrcivilgate@gmail.com

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10. The following statements are related to temperature stresses developed in concrete pavement slabs with free edges (without any restraint): CE1 2014

P. The temperature stresses will be zero during both day and night times if the pavement slab is considered weightless

Q. The temperature stresses will be compressive at the bottom of the slab during night time if the self weight of the pavement slab is considered

R. The temperature stresses will be compressive at the bottom of the slab during day time if the self weight of the pavement slab is considered

The TRUE statement(s) is(are)

a. P only b. Q only **c.** P and Q only d. P and R only

10. c

Temperature differential between the top and bottom of the slab causes warping stress in the pavement. If the temperature of the top surface of the slab is higher than the bottom surface, then top surface tends to expand and the bottom surface tends to contract resulting in compressive stress at the top, tensile stress at the bottom and vice versa.

No warping stresses will induce if the pavement slab is not restrained.

Temperature differential produces two types of stresses in a concrete pavement.

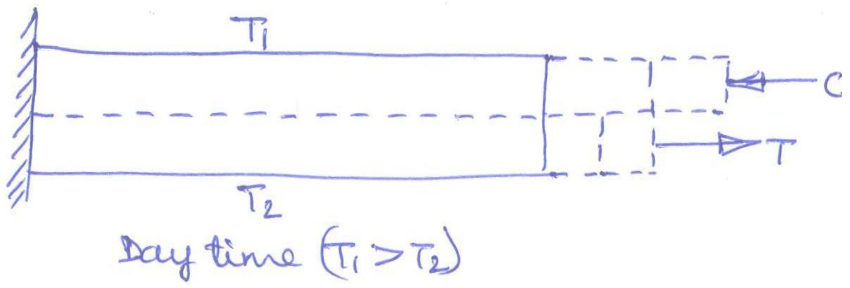
i. Warping stresses and ii. Frictional stresses

Since the slab is in contact with the soil subgrade, the slab movements are restrained due to friction. The frictional resistance tends to prevent the slab movement and thereby inducing the frictional stress at the bottom of the slab pavement.

During summer, as the mean temperature of the slab increases, the concrete pavement expands towards the expansion joints. The frictional resistance depends on the self weight of the slab and coefficient of friction at the interface. Due to friction resistance at the interface, compressive stress is induced at the bottom of the slab.

Similarly, during winter as the mean temperature of the slab decreases, the concrete pavement contracts. Due to frictional resistance at the interface, tensile stress is induced at the bottom of the slab.

No frictional stresses will induce if the weight of the pavement is neglected.



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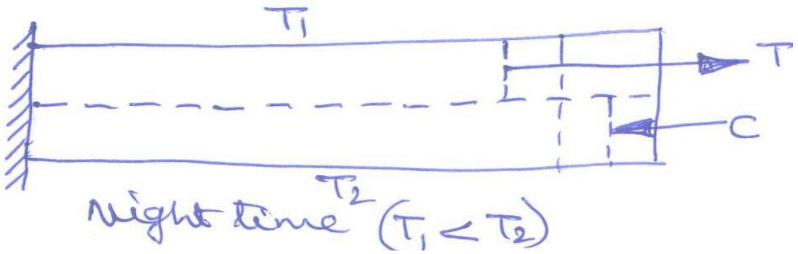

During the day, the top of the pavement slab gets heated under the sunlight when the bottom of the slab still remains relatively colder. Due to frictional resistance, tensile stresses induced at bottom during the day.

During the night (or late in the evening), the bottom of the slab gets heated up due to heat transfer from the top. Due to frictional resistance, compressive stress induced at the bottom during the night.

Therefore, it can be concluded that

P. The temperature stress will be zero during both day and night if the pavements slab is considered weightless.

Warping stress = 0 (no restraint at edges)

Frictional stress = 0 (pavement slab is weightless)

Statement P is true

Q. The temperature stress will be compressive at the bottom of the slab during night time if the self weight of pavement is considered.

Warping stress = 0 (no restraint at edges)

Frictional stress = compressive

Statement Q is true.

R. The temperature stress will be tensile at the bottom of the slab during day time if the self weight of the pavement slab is considered.

Warping stress = 0 (no restraint at edges)

Frictional stress = tensile

Statement R is false.

11. Select the strength parameter of concrete used in design of plain jointed cement concrete pavements from the following choices: GATE 2013

a. Tensile strength b. Compressive strength

c. Flexural strength d. Shear strength.

11. c

Flexural strength of concrete used in design of plain jointed cement concrete pavements.

12. A pavement designer has arrived at a design traffic of 100 million standard axles for a newly developing National highway as per IRC: 37 guidelines using the following data: design life = 15 years, commercial vehicle count before pavement construction = 4500 vehicles/day, annual traffic growth rate = 8%. The vehicle damage factor used in the calculation was GATE 2012

a. 1.53 **b.** 2.24 c. 3.66 d. 4.14

12. b

Number of standard axle load, N_S = 100 msa

Design life, n = 15 years

Commercial vehicle count before pavement construction, A = 4500 vehicles/day

Annual traffic growth rate, r = 8%

Vehicle damage factor, F =?

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$$N_S = \frac{365A\left[(1+r)^n - 1\right]}{r} \cdot F$$

$$100 \times 10^6 = \frac{365 \times 4500[(1+0.08)^{15} - 1]}{0.08} \cdot F$$

$$F = 2.24$$

13. Consider the following statements in the context of cement concrete pavements.

I. Warping stresses in cement concrete pavements are caused by the seasonal variation in temperature.

II. Tie bars are generally provided across transverse joints of cement concrete pavements

The correct option evaluating the above statements is GATE 2010

a. I: True II: False b. I: False II: True c. I: True II: True d. I: False II: False

13. d

Warping stresses in cement concrete pavements are used by the daily variation in temperature. The bars are generally provided across the longitudinal joints of cement concrete pavements.

14. Which of the following stress combinations are appropriate in identifying the critical condition for the design of concrete pavements ? GATE 2009

Type of stress	**Location**
P. Load	1. Corner
Q. Temperature	2. Edge
	3. Interior

a. P2 Q3 b. P1 Q3 c. P3 Q1 d. P2 Q2

14. a

The critical condition for load is at the edge for the design of concrete pavements. Frictional stresses are developed due to seasonal variation in temperature. The frictional stresses will be zero at the free and ends at expansion joints and increases up to a maximum value towards the interior. Therefore, critical condition for the design of concrete pavements due to temperature is interior.

16. It is proposed to widen and strengthen an existing 2-lane NH section as a divided highway. The existing traffic in one direction is 2500 commercial vehicles (CV) per day. The construction will take 1 year. The design CBR of soil subgrade is found to be 5 percent. Given: traffic growth rate for CV = 8 percent, vehicle damage factor = 3.5 (standard axles per CV), design life = 10 years and traffic distribution factor = 0.75. The cumulative standard axles (msa) computed are GATE 2008

a. 35 **b.** 37 c. 65 d. 70

16. b

Existing traffic in one direction, P = 2500 CV per day

Period of construction, n = 1 year

CBR of soil sub grade = 5%

Traffic growth rate for CV, r = 8%

Vehicle damage factor, F = 3.5

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Design life, n = 10 years

Traffic distribution factor = 0.75

Cumulative standard axles = N_S

Number of vehicles after 1 year, $A = P(1+r)^n$

$$A = 2500\left(1+\frac{8}{100}\right)^1 = 2700 \text{ CV per day}$$

Cumulative standard axles (msa) $N_S = \frac{365A\left[(1+r)^n - 1\right]}{r} \times F \times D$

$$N_S = \frac{365 \times 2 \times 2700\left[(1+0.08)^{10} - 1\right]}{0.08} \times 3.5 \times 0.75 = 74.94 \times 10^6 \text{ sa} = 74.94 \text{ msa}$$

Cumulative standard axles per lane = 37.47 msa

17. The following data pertains to the number of commercial vehicles per day for the design of a flexible pavement for a national highway as per IRC:37-1984

Type of commercial Vehicle	Number of vehicles per day	Damage Factor
Two axle trucks	2000	5
Tandem axle trucks	200	6

Assuming a traffic growth factor of 7.5% per annum for both the types of vehicles, the cumulative number of standard axle load repetitions (in million) for a design life of ten years is GATE 2007

a. 44.6 **b.** 57.8 c. 62.4 d. 78.7

17. b

Cumulative number of standard axle load repetitions is given by

$$N_s = \frac{365\, A[(1+r)^n - 1]}{r}.F$$

Number of vehicles per day considering the number of lanes, A =2000

Traffic growth rate, r = 7.5 %

Vehicle damage factor, F = 5

Design life of pavement, n = 10 years

For two axle trucks, A = 2000, F = 5

$$N_{s1} = \frac{365 \times 2000[(1+0.075)^{10} - 1]}{0.075} \times 5 = 51.6 \times 10^6 = 51.6 \text{ msa}$$

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For Tandem axle trucks, $A = 200$, $F = 6$

$$N_{s2} = \frac{365 \times 200[(1+0.075)^{10} - 1]}{0.075} \times 6 = 6.2 \times 10^6 = 6.2 \text{ msa}$$

$$N_s = N_{s1} + N_{s2} = 51.6 + 6.2 = 57.8 \text{ msa}$$

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18. The width of the expansion joint is 20 mm in a cement concrete pavement. The laying temperature is 20^0C and the maximum slab temperature in summer is 60°C. The coefficient of thermal expansion of concrete is 10×10^{-6} mm/mm/^{o}C and the joint filler compresses up to 50% of the thickness. The spacing between expansion joints should be GATE 2007

a. 20 m **b.** 25 m c. 30 m d. 40 m

18. b

Width of expansion joint, $\delta = 20\,\text{mm}$

The Laying temperature, $T_1 = 20^0 C$

Maximum slab temperature during summer, $T_2 = 60^0 C$

Coefficient of thermal expansion, $\alpha = 10 \times 10^{-6}$ mm/mm/^{o}C

Compression of the filler joint = 50% of the thickness

Compression of the filler, $\delta' = 0.5 \times 20$ =10 mm =1 cm

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Spacing of expansion joint, $L_e = \dfrac{\delta'}{\alpha(T_2 - T_1)}$

$$L_e = \frac{10}{10 \times 10^{-6}(60-20)} = 25 \times 10^3 = 25 \text{ m}$$

OR

$\delta = L\,\alpha\,T$ $\quad 10 = L \times 10 \times 10^{-6} \times 40$ $\quad L = 25 \times 10^3 \text{ mm} = 25 \text{ m}$

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19. Using IRC : 37-1984 “Guidelines for the Design of Flexible Pavements” and the following data, choose the total thickness of the pavement. GATE 2006

No. of commercial vehicles when construction is completed = 2723 veh/day

Annual growth rate of the traffic = 5.0%

Design life of the pavement = 10 years

Vehicle damage factor = 2.4

CBR value of the subgrade soil = 5%

Data for 5% CBR value

No. of Standard Axels, msa	Total Thickness, mm
20	620
25	640
30	670
40	700

a. 620 mm b. 640 mm **c.** 670 mm d. 700 mm

19. c

Cumulative number of standard axle load is given by

$$N_s = \frac{365A\left[(1+r)^n - 1\right]}{r} \times F$$

Number of commercial vehicles per day when construction is completed,

A = 2723 vehicles / day

Annual growth rate of the traffic, r = 5.0%

Design life of the pavement, n = 10 years

Vehicle damage factor, F = 2.4

CBR value of the sub grade soil = 5%

$$N_s = \frac{365 \times 2723\left[(1+0.05)^{10} - 1\right]}{0.05} \times 2.4 = 30 \times 10^6$$

N_s = 30 msa

From the given table, for 5% CBR value, the total thickness of pavement for 30 msa is 670 mm.

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20. In case of governing equations for calculating wheel load stresses using Westergaard's approach, the following statements are made. GATE 2006

I. Load stresses are inversely proportional to wheel load

II. Modulus of subgrade reaction is useful for load stress calculation

a. Both statements are TRUE

b. I is TRUE and II is FALSE

c. Both statements are FALSE

d. I is FALSE and II is TRUE

20. d

The critical stress S_i at interior is given by

$$S_i = \frac{0.316P}{h^2}\left[4\log_{10}\left(\frac{l}{b}\right)+1.069\right]$$

P :Wheel load, kg

h : Slab thickness

b : Radius of resisting section

l : Radius of relative stiffness = $\left[\dfrac{Eh^3}{12k(1-\mu^2)}\right]^{1/4}$

k : Modulus of subgrade reaction

Load stress is directly proportional to wheel load.

Modulus of subgrade reaction (k) is useful for load stress calculation.

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21. The following observations were made of an axle-load survey on a road

Axle Load KN	**Repetitions per day**
35-45	800
75-85	400

The standard axle-load is 80 kN. Equivalent daily number of repetitions for the standard axle-load are GATE 2005

a. 450 b. 480 c. 800 d. 1200

21. a

Axle load, kN	Avg. axle load, kN	Repetitions per day	EALF
35-45	40	800	1/16
75-85	80	400	1

$$\text{Equivalent Axle Load Factor (EALF)} = \left(\frac{W_i}{W_{std}}\right)^4$$

W_i : Axle load of i^{th} vehicle

W_{std} : Standard axle load.

Equivalent daily number of repetitions for the standard axle load

$$= 800 \times \frac{1}{16} + 400 \times 1 = 450$$

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22. For a 25 cm thick cement concrete pavement, analysis of stresses gives the following values.

Wheel load stress due to corner loading = 30 kg/cm^2

Wheel load stress due to edge loading = 32 kg/cm^2

Warping stress at corner region during summer = 9 kg/cm^2

Warping stress at corner region during winter= 7 kg/cm^2

Warping stress at edge region during summer= 8 kg/cm^2

Warping stress at edge region during winter= 6 kg/cm^2

Frictional stress during winter = 5 kg/cm^2

Frictional stress during winter = 4 kg/cm^2

The most critical stress value for this pavement is GATE 2005

a. 40 kg/cm^2 **b.** 42 kg/cm^2 c. 44 kg/cm^2 d. 45 kg/cm^2

22. b

The following four cases are to be considered for most critical stress value for pavement.

i. During summer, critical combination of stresses at edges

= Wheel load stress due to edge loading + warping stress at edge region during summer – frictional stress during summer

$= 32 + 8 – 5 = 35\ kg / cm^2$

ii. During winter, critical combination of stresses at edges

= Wheel load stress due to edge loading + warping stress at edge region during winter + frictional stress during winter

$= 32 + 6 + 4 = 42\ kg/cm^2$

iii. During summer, critical combination of stresses at corner

= Wheel load stress at corner loading + warping stress at corner region during summer

= 30 + 9 = 39 kg/cm^2

iv. During winter, critical combination of stresses at corner

= Wheel load stress at corner loading + warping stress at corner region during winter

= 30 + 7 = 37 kg/cm^2

Hence, the most critical stress value for the pavement = 42 kg/cm^2

23. The data given below pertain to the design of a flexible pavement. GATE 2004

Initial traffic = 1213 cvpd

Traffic growth rate = 8 percent per annum

Design life = 12 years

Vehicle damage factor = 2.5

Distribution factor = 1.0

The design traffic in terms of million standard axles (msa) to be catered would be

a. 0.06 msa b. 8.40 msa **c.** 21.00 msa d. 32.26 msa

23. c

Initial traffic, A = 1213 cvpd

Traffic growth rate, r = 8%

Design life of pavement, n = 12 years

Vehicle damage factor, F = 2.5

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Distribution factor = 1.0

Design traffic is in msa.

Standard Axles, $N_s = \frac{365A\left[(1+r)^2 - 1\right]}{r}.F = \frac{365 \times 1213\left[(1+0.08)^{12} - 1\right]}{0.08} \times 2.5$

$= 21.0 \times 10^6$ standard axles = 21.0 msa

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24. In the context of flexible pavement design, the ratio of contact pressure to tyre pressure is called the Rigidity Factor. This factor is less than unity when the tyre pressure is GATE 2004

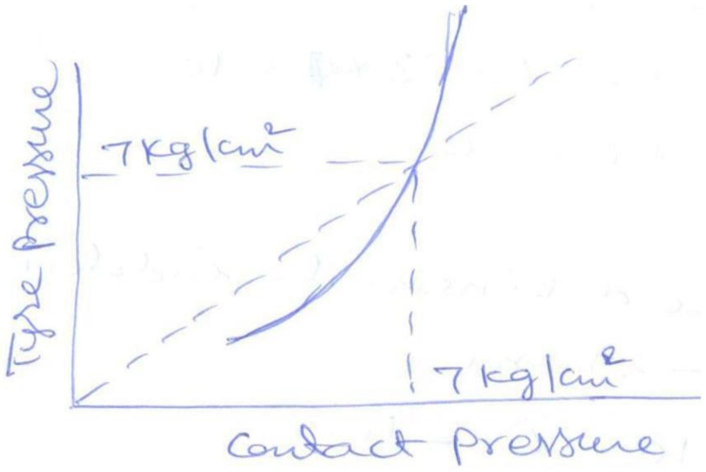
a. less than 0.56 N/mm^2
b. equal to 0.56 N/mm^2
c. equal to 0.7 N/mm^2
d. more than 0.7 N/mm^2

24. d

$$\text{Rigidity factor} = \frac{\text{Contact Pressure}}{\text{Tyre pressure}}$$

Rigidity factor	Average tyre pressure
1	7 kg/cm^2 (0.7 N/mm^2)
>1	< 7 kg/cm^2 (<0.7 N/mm^2)
<1	>7 kg/cm^2 (> 0.7 N/mm^2)

The rigidity factor depends upon the degree of tension developed in the walls of the tyres.



25. The plate load test conducted with a 75 cm diameter plate on soil sub grade yielded a deflection of 2.5 mm under a stress of 800 N/cm^2. The modulus of elasticity of the subgrade soil, in kN/cm^2, is GATE 2003

a. 141,6 b. 154.6 c. 160.0 d. 185.4

25. a

The modulus of elasticity of sub grade soil is given by

$$E_s = \frac{1.18\,p.a}{\Delta}$$

Radius of the plate, $a = \frac{75}{2}$ = 37.5 cm

Deflection, Δ = 2.5 mm = 0.25 cm

Intensity of stress, p = 800 N/cm^2

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$$E_s = \frac{1.18 \times 800 \times 37.5}{0.25} = 141600 \text{ N/cm}^2 = 141.6 \text{ KN/cm}^2$$

26. Temperature stresses in concrete pavements may cause the slab to crack. If a slab cools uniformly, then the crack will develop at the following locations of the slab

a. at centre   b. near edges   c. at corners   d. both (b) and (c)

GATE 2003

26. a

Temperature stresses are developed in cement concrete pavement due to variation in slab temperature. Temperature produces two types of stresses in a concrete pavement

i. Warping stress and

ii. Frictional stress

If a slab cools uniformly, the corners and edges are free to contact. Hence the cracks due to stresses will develop at the center of the slab.

27. In a concrete pavement GATE 2002

A. temperature stress is tensile at bottom during day time.

B. load stress is compressive at bottom

a. Both the statements (A) and (B) are correct

b. Statement (A) is correct and (B) is wrong

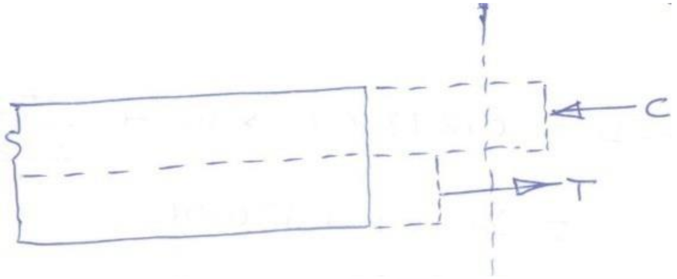
c. Statement (B) is wrong and (A) is correct

d. Both statement (A) and (B) are incorrect

27. b

The top surface expands more than the bottom surface.

Temperature differential between the top and bottom of the slab causes curling (warping) stress in the pavement. During the day time, the bottom of pavement is subjected to low temperature than at the top. If the temperature of the upper surface of the slab is higher than the bottom surface then top surface tends to expand and the bottom surface tends to contract resulting in compressive stress at the top, tensile stress at bottom.



Forces acting on pavement during the day.

The top surface pull the bottom surface and bottom surface push the top surface so that the section expands the same amount. Hence, bottom surface of pavement is subjected to tensile stress and top surface subjected to compressive stress. Statement A is true.

Load stress is tensile at bottom of interior and edge locations and at top of the corner. Statement B is false.

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28. The average daily traffic on a stretch of road is 300 commercial vehicles per lane per day. Design traffic repetitions for 10 years when vehicle damage factor is 2.5 and traffic growth rate is 7%, is GATE 2002

a. 3.8 msa b. 23.5 msa c. 45.4 msa d. 16 msa

28. a

Average daily traffic on a road, $A = 300$ cvld

Design period, $n = 10$ years

Vehicle damage factor, $F = 2.5$

Traffic growth, $r = 7\%$

Cumulative standard axles, $N_s = \dfrac{365\,A\left[(1+r)^n - 1\right]}{r}.F$

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$$N_s = \frac{365 \times 300\left[(1+0.07)^{10} - 1\right]}{0.07} \times 2.5 = 3.78 \times 10^6 \text{ sa}$$

$$N_s = 3.78 \text{ msa}$$

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29. Dowel bars in concrete pavement are placed GATE 2002

a. along the direction of traffic

b. perpendicular to the direction of traffic

c. along 45^0 to the direction of traffic

d. can be placed along any direction

29. a

Dowel bars in concrete pavement are used in expansion joints ie., along the direction of traffic.

Tie bars are used across the longitudinal joints of cement concrete pavements ie., perpendicular to the direction of traffic.

30. The radius of relatives stiffness for a 20 cm thick slab with $E = 3\times10^5$ kg/cm^2 and poisson's ratio = 0.15, resting on a subgrade having modulus of 5 kg/cm^3 is

a. 10 cm **b.** 80 cm c. 120 cm d.320 cm GATE 2001

30. b

Thickness of slab, $h = 20$ cm

Modulus of elasticity, $E = 3\times10^5$ kg/cm^2

Poisson's ratio, $\mu = 0.15$

Modulus of subgrade reaction, $K = 5$ kg/cm^3

Radius of relative stiffness, $l = ?$

$$l = \frac{E.h^3}{12K(1-\mu^2)} = \frac{3\times10^5\times20^3}{12\times5(1-0.15^2)} = 79.98 \text{ cm}$$

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31. The minimum value of CBR(%) required for granular sub-base as per Ministry of Surface Transport (MOST) specification is GATE 2001

a. 5 b. 10 c. 15 **d.** 20

31. d

For sub-grade, minimum CBR value=10%

For granular sub-base, minimum CBR value of 20% for cumulative traffic upto 2 msa and 30% exceeding 2 msa.

32. The standard plate size in a plate bearing test for finding modulus of subgrade reaction (k) value is GATE 2000

a. 100 cm diameter

b. 50 cm diameter

c. 75 cm diameter

d. 25 cm diameter

32. c

For finding the modulus of subgrade reaction, 75 cm diameter plate is used in a plate bearing test

33. A two lane single carriage-way is to be designed for a design life period of 15 years. Total two-way traffic intensity in the year of completion of construction is expected to be 2000 commercial vehicles per day. Vehicle damage factor = 3.0, Lane distribution factor = 0.75. Assuming an annual rate of traffic growth as 7.5%, the design traffic expressed as cumulative number of standard axles, is

a. 42.9×10^6 b. 22.6×10^6 c. 10.1×10^6 d. 5.3×10^6 GATE 1999

33. a.

Design life period, n = 15 years

Traffic intensity in the year of completion of construction, A=2000 cvpd

Vehicle damage factor, F =3.0

Lane distribution factor = 0.75

Annual rate of traffic growth, r = 7.5%

Design traffic, $N_s = ?$

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$$N_s = \frac{365A\left[(1+r)^n - 1\right]}{r}.F = \frac{365 \times 2000 \times 0.75\left[(1+0.075)^{15} - 1\right]}{0.075} \times 3 = 42.9 \times 10^6 \text{sa}$$

$$N_s = 42.9 \text{ msa}$$

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34. Plate bearing test with 30 cm diameter plate on soil subgrade yielded a pressure of 1.25×10^5 N/mm^2 at 0.5 cm deflection. What is the elastic modulus of subgrade? GATE 1998

a. 56.18×10^5 N/mm^2

b. 22.10×10^5 N/mm^2

c. 44.25×10^5 N/mm^2

d. 50.19×10^5 N/mm^2

34. c

Diameter of the plate, d = 30cm

Radius of the plate, a =15 cm

Pressure on sub grade, $p = 1.25 \times 10^5 \, N/m^2$

Deflection, Δ =0.5cm

For rigid plate, $\Delta = \dfrac{1.18 p.a}{E_s}$

$$E_s = \frac{1.18 \times 1.25 \times 10^5 \times 15}{0.5} = 44.25 \times 10^5 \, N/m^2$$

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35. What is the equivalent single wheel load of a dual wheel assembly carrying 20,440 N each for pavement thickness of 20 cm?. Centre to centre spacing of tyres is 27 cm and the distance between the walls of tyres is 11 cm.

a. 27600 N   b. 32300 N   c. 40880 N   **d.** 30190 N

GATE 1998

35. d

Pavement thickness, $t = 20\text{cm}$

Distance of wall of tyres, $d = 11\text{cm}$

c/c of type spacing, $S = 27\text{cm}$

To calculate ESWL, X and Y points are plotted on log-log graph between ESWL and pavement thickness

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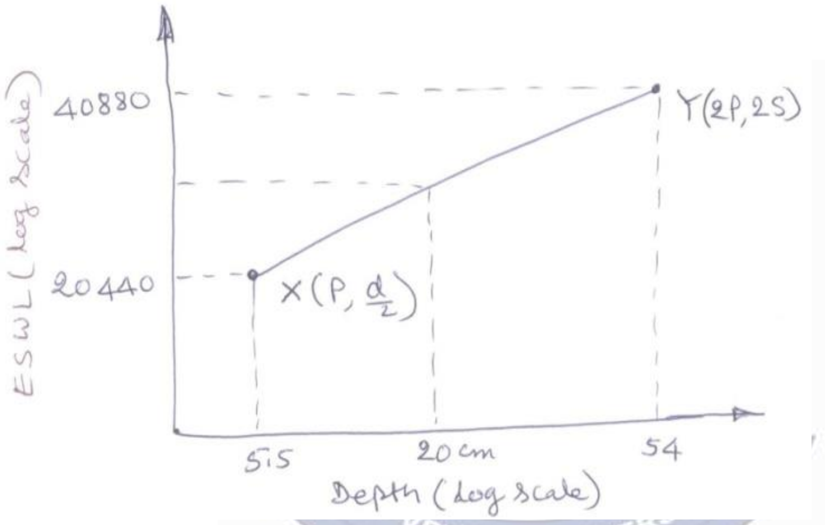
X has coordinates $(P, d/2) = (20440, 5.5)$

Y has coordinates (2P,2S)=(40880,54) $(2P, 2S) = (40880, 54)$



$$\log Q = \log P + \frac{\log 40880 - \log 20440}{\log 54 - \log 5.5} \times (\log 20 - \log 5.5)$$ =4.4806

$$Q = 30242 \text{ N}$$

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36. Base course is used in rigid pavements for GATE 1998

a. prevention of sub grade settlement b. prevention of slab cracking

c. preventing of pumping d. preventing of thermal expansion

36. c

Base course is used in rigid pavements

i. to provide a strong supporting layer

ii. to provide a capillary cut off preventing the damages due to mud pumping

iii. to reduce the thickness requirements of cement concrete slab

iv. to increase the service life of cement concrete pavement

37. In the plate bearing test, if the load applied is in the form of an inflated type of wheel, then this mechanism corresponds to GATE 1998

a. rigid plate b. flexible plate **c.** semi-rigid plate d. semi-elastic plate

37. c

The plate load test is used to measure the modulus of subgrade reaction for in situ material. The test involves pressing a steel bearing plate into the surface to be measured with a hydraulic jack. The resulting surface deflection is read from dial micrometers near the plate edge and the modulus of subgrade reaction is determined.

Flexible plate is flexible in their structural action with low or negligible flexural strength under the action of loads.

Rigid plate provides high bending resistance (flexural rigidity) and distributes loads to a relatively large area.

Semi-rigid plate provides moderate flexural rigidity and flexible to certain extent under the action of loads.

38. The modulus of sub grade reaction is obtained from the plate bearing test in the form of load deformation curve. The pressure corresponding to the following settlement value should be used for computing modulus of subgrade reaction

a. 0.375 cm b. 0.175 cm **c.** 0.125 cm d. 0.250 cm

GATE 1998

38. c

In plate bearing test, the modulus of subgrade reaction is the pressure sustained for a standard plate (75 cm dia) settlement of 0.125 cm.

40. The width of expansion joint gap is 2.5 cm in a cement concrete pavement. The spacing between expansion joint for a maximum rise in temperature of 25°C is, (assuming coefficient of thermal expansion of concrete as 10×10^{-6} per degree C)

a. 5 m **b.** 50 m c. 100 m d. 25 m GATE 1997

40. b

Width of expansion joint gap, δ =2.5 cm

The joint filler may be assumed to be compressed upto 50% of its thickness.

Allowable expansion in concrete, $\delta' = \dfrac{\delta}{2} = 1.25$ cm

Spacing between expansion joint = L

Rise in temperature, $T = 25^0 C$

Coefficient of thermal expansion of concrete, $C = 10\times10^{-6}/^0$ C

$\delta' = L.\alpha.T$ $1.25\times10^{-2} = L\times10\times10^{-6}\times25$ L = 50 m

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41. The total thickness of pavement by CBR method depends on the CBR value of

a. base course   b. surface course   c. subgrade   **d.** all layers

GATE 1997

41. d

The total thickness of pavement depends on the CBR value of surface course, base course and subgrade.

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42. The group index of a soil subgrade is 7. The subgrade soil is rated as

a. poor b. very poor c. good d. fair

GATE 1997

42. a

Group Index	Subgrade of soil
10 – 20	Very poor
5 – 9	Poor
2 – 4	Fair
0 – 1	Good

43. Since the moisture content at the bottom of a rigid pavement slab is generally more than at the top GATE 1996

a. the bottom of the slab is generally in tension

b. the top of the slab is generally in compression

c. the bottom of the slab is generally in compression

d. the bottom of the slab is neither compression nor in tension

43. a.

If the moisture content at the bottom of the slab is more, the slab will contract from its natural shape and hence tensile stress is induced at the bottom of the slab.

44. Flexible pavements derive stability primarily from GATE 1996

a. aggregate interlock, particle friction and cohesion

b. cohesion alone

c. the binding power of bituminous materials

d. the flexural strength of the surface course

44. a

Flexible pavements derive stability primarily from aggregate interlock, particle friction and cohesion.

45. In using the data from a plate bearing test for determining the modulus of sub-grade reaction, the value of settlement to be used is GATE 1995

a. 1.25 mm b. 2.50 mm c. 3.75 mm d. 1.75 mm

45. a

If p is the pressure sustained in kg/cm^2 by the rigid plate of diameter $75\,\text{cm}$ at a deflection $\Delta = 0.125\,\text{cm}$, the modulus of subgrade reaction K is given by

$$K = \frac{p}{\Delta} = \frac{p}{0.125}\,\text{kg/cm}^3$$

046. A plate bearing test was carried out on a subgrade suing a 76 cm diameter rigid plate. A deflection of 1.25 mm was caused by a pressure of 0.84 kg/m^2. The modulus of subgrade reaction in kg/cm^3 is ………….. GATE 1993

46. 6.81 kg/cm^3

Diameter of rigid plate, $d_1 = 76$ cm

Deflection of plate, $\Delta = 1.25$ mm

Pressure sustained, $p = 0.84$ kg/cm^2

Modulus of subgrade reaction, $K_1 = \frac{p}{\Delta}$ $K_1 = \frac{0.84}{0.125} = 6.72$ kg/cm^3

Diameter of standard rigid plate, $d = 75$ cm

$K.a = K_1.a_1$ $K \times 75 = 6.72 \times 76$ $K = 6.81$ kg/cm^3

47. A contraction joint is provided in concrete pavement to GATE 1993

a. prevent contraction of the pavement

b. permit cracking at the joint

c. lower the bending moment in the pavement in order to reduce pavement thickness

d. lower the temperature gradient across the depth of the pavement

47. a

A contraction joint is provided in concrete pavement to prevent contraction of the pavement. These joints are closer than expansion joints. Load transferred at the joints is provided through the physical interlocking by the aggregates projecting out at the joint faces.

48. In a cement concrete pavement dowel bars are used in GATE 1992

a. longitudinal joints
b. construction joints
c. dummy joints
d. expansion joints

48. d

In cement concrete pavement, Dowel bars are provided at expansion joints and sometimes at contraction joints also.

In cement concrete pavement, tie bars are provided across the longitudional joints.

49. The load transfer to lower layers in flexible pavements is by GATE 1992

a. bending action of layers
b. shear deformation
c. grain to grain contact
d. consolidation of subgrade

49. c

In flexible pavements, load transfer to the lower layers by grain to grain contact.

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50. The Modulus of subgrade Reaction is evaluated from GATE 1992

a. plate bearing test

b. CBR test

c. direct shear test

d. triaxial test

50. a

Name of the test	Parameter evaluation
Plate bearing test	Modulus of sub-grade reaction
CBR test	Relative strength of paving materials
Direct shear test	Shear strength parameters c and ϕ
Triaxial test	Shear strength parameters c and ϕ

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52. The position of base course in a flexible pavement is GATE 1991

a. over the sub-base

b. below the sub-base

c. over the sub-grade but below the sub-base

d. over the wearing course when renewal of surface is needed

52. a

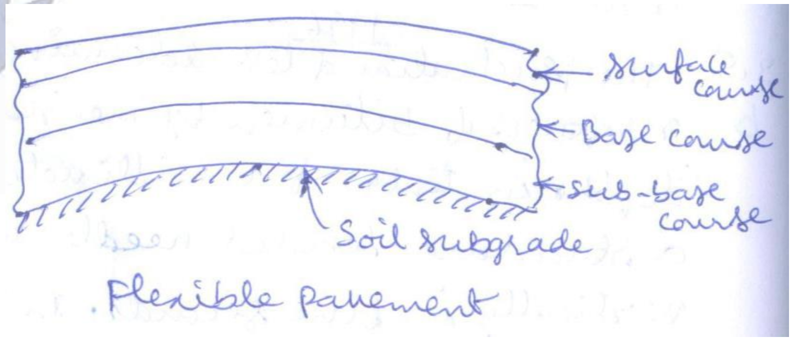
The components of flexible pavements are

i. Soil-sub grade

ii. Sub-base course

iii. Base course

iv. Surface course



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01. Consider the following data with respect to the design of flexible pavement IES 2019

Design wheel load =4200kg

Tyre pressure = 0.6 kg/cm2

Elastic modulus = 150 kg/cm2

Permissible deflection =0.25cm

$$(take\ \pi^{1/2} = 1.77,\ \pi^{-1/2} = 0.564,\ \frac{1}{\pi} = 0.318\ and\ \pi^2 = 9.87)$$

The total thickness of flexible pavement for a single layer elastic theory will be nearly

a. 42cm b. 47cm **c.** 51cm d. 56cm

Ans. c

Design wheel load, P = 4200 kg

Tyre pressure, p = 6.0 kg/cm^2

Elastic modulus, E = 150 kg/cm^2

Permissible deflection, Δ = 0.25 cm

Total thickness of flexible pavement, t = ?

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$$t = \sqrt{\left(\frac{3P}{2\pi E_S \Delta}\right)^2 - a^2} \quad ; \qquad a : \text{Radius of contact area, cm}$$

$$p = \frac{P}{\pi a^2}$$

$$6 = \frac{4200}{\pi a^2} \Rightarrow a = 14.92\,cm$$

$$t = \sqrt{\left(\frac{3 \times 4200}{2\pi \times 150 \times 0.25}\right)^2 - 14.92^2} = 51.3\,cm$$

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04. In revised CBR design method recommended by the IRC for the design of flexible pavement, the total thickness depends upon IES 2017

a. Only the CBR value of the soil

b. The CBR value of the soil and magnitude of wheel load

c. The CBR value of the soil and cumulative standard axle loads

d. The CBR value of the soil and number of commercial vehicles passing per day

Ans. c

05. What is the critical thickness of a pre-stressed concrete pavement (using Westergaard's Corner Load Formula) to support a maximum wheel load of 4200 kg? Allow 10% for impact. Type pressure may be taken as 7 kg/cm^2. Assume flexural strength of concrete as 50 kg/cm^2, factor of safety as 2, sub-grade reaction for plastic mix road as 6 kg/cm^3, and modulus of elasticity as 3×10^5 kg/cm^2. IES 2016

a. 19.6 cm b. 21.6 cm **c.** 23.6 cm d. 25.6 cm

Ans. c

Critical thickness of pre stressed concrete pavement = ?

Maximum wheel load, P = 4200 kg

Impact factor = 10%

Tyre pressure = 7 kg/cm^2

Flexural strength of concrete = 50 kg/cm^2

Factor of safety, F = 2

Sub grade reaction for plastic mix road = 6 kg/cm^2

Modulus of elasticity, $E = 3 \times 10^5$ kg/cm^2

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Westergaard's corner load stress is given by, $S_C = \frac{3P}{h^2}\left[1-\left(\frac{a\sqrt{2}}{l}\right)^{1/2}\right]$

l : Radius of relative stiffness $= \left[\frac{Eh^3}{12k(1-\mu^2)}\right]^{1/4}$ = 3x10^5

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06. What will be the initial traffic after construction, in commercial vehicles per day (CVD) for the following data? IES 2015

Annual average daily traffic at last count = 400 CVD

Rate of traffic growth per annum = 7%

The road is proposed to be completed in 3 years.

a. 500 b. 321 **c.** 490 d. 449

Ans. c

Initial traffic after construction, A = ?

Annual average daily traffic at last count, P = 400 CVD

Rate of traffic growth per annum, r = 7%

Completion time of road, n = 3 years

$A = P(1+r)^n = 400(1+0.07)^3 = 490$ CVD

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07. In a flexible pavement IES 2014

a. Vertical compressive stresses decrease with depth of the layer

b. The vertical compressive stress is the maximum at the lowest layer

c. Tensile stresses get developed

d. Maximum stress induced by a given traffic load is dependent on the location of the load on the pavement surface

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08. What is the deflection at the surface of a flexible pavement due to a wheel load of 40 KN and a tyre pressure of 0.5 MPa? The value of E for pavement and sub-grade is 20 MPa. IES 2014

a. 15 mm b. 11 mm c. 9 mm **d.** 6 mm

Ans. d

Deflection at the surface of a flexible pavement = ?

Wheel load, P = 40 KN Tyre pressure, due to wheel load p = 0.5 MPa

Modulus of elasticity for pavement and sub grade, ES = 20 MPa

For flexible plate, $\Delta = 1.5 \dfrac{pa}{E_S}.F_2$; a : Radius of contact area

$$\text{Contact area, A} = \frac{\text{Wheel load}}{\text{Tyre Pressure}} = \frac{40 \times 10^3}{0.5} = 80 \times 10^3 \text{ mm}^2$$

$$\pi a^2 = 80 \times 10^3 \, mm^2 \Rightarrow a = 159.6 \, mm$$

$$\Delta = \frac{1.5 \times 0.5 \times 159.6}{20} \times 1 = 5.99 \, mm \approx 6.0 \, mm$$

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09. The corrected modulus of sub-grade reaction for standard diameter plate is 6.0 kg/cm^3. What would be the modulus of sub-grade reaction of the soil when tested with a 30 cm diameter plate? IES 2013

a.15 kg/cm^3 b. 25 kg/cm^3 c. 30 kg/cm^3 d. 60 kg/cm^3

Ans. a

Corrected modulus of sub grade reaction, K = 6.0 kg/cm^3

Standard diameter of plate, D = 75 cm

Modulus of sub grade reaction, K_1 = ?

Diameter of the plate tested, D_1 = 30 cm

$K_1.D_1 = K.D$

$K_1 \times 30 = 6 \times 75 \Rightarrow K = 15$ kg/cm^2

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13. The sub grade soil properties of a sample are as follows: IES 2011

Soil portion passing 0.0075mm sieve = 50%

Liquid limit = 40%

Plasticity index = 20%

The group index of the soil is

a. Zero b. 4 **c.** 6.5 d. 8

Ans. c

Group index of the soil, $GI = 0.2a+0.005a.c+0.01b.d$

$a = 50-35 = 15$

$b = 50-15 = 35$

$c = 40-40 = 0$

$d = 20-10 = 10$

$GI = (0.2x15)+(0.005x15x0)+(0.01x35x10) = 6.5$

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15. In a concrete pavement, during summer, at and soon after mid-day, the combined stress at the interior of the slab is equal to IES 2011

a. Wheel load stress + Temperature warping stress + sub grade resistant stress

b. Wheel load stress – Temperature warping stress + sub grade resistant stress

c. Wheel load stress – temperature warping stress + sub grade resistant stress

d. Wheel load stress – temperature warping stress – sub grade resistant stress

19. Which one of the following sets of factors is related to design of thickness rigid pavement by Westergaard method? IES 2009

a. CBR value and stiffness index of soil

b. Deflection factor and traffic index

c. Swelling index and bulk modulus

d. Radius of relative stiffness and modulus of sub-grade reaction

Ans. d

20. For conditions obtaining in India, at which location in a cement concrete pavement will the combined stresses due to traffic wheel load and temperature have to be critically checked during design? IES 2009

a. Corner

b. Corner and interior

c. Corner and edge

d. Corner, edge and interior

Ans. c

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21. Radius of relative stiffness of cement concrete pavement does not depend upon which one of the following? IES 2009

a. Modulus of sub-grade reaction **b.** Wheel load

c. Modulus of elasticity of cement concrete d. Poisson’s ratio of concrete

Ans. b

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22. Which one of the following methods is used in the design of rigid pavements?

IES 2009

a. CBR method
b. Group index method
c. Westergaard's method
d. McLeod's method

Ans. c

23. IRC code No.37-1985 deals with which one of the following? IES 2008

a. Design of rigid pavements, taking ESWL and CBR into account

b. Design of rigid pavements, taking axle load and CBR into account

c. Design of flexible pavement, taking ESWL and CBR into account

d. Design of flexible pavement taking cumulative axle loads and CBR into account

Ans. d

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26. What are the maximum value of CBR and minimum value of G.I. of any material, respectively? IES 2007

a. 100, 0 b. 100, 20 c. 50, 5 d. 10, 0

Ans. a

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29. Which one of the following criteria is used for obtaining the value of modulus of sub-grade reaction from the plate bearing test data? IES 2007

a. Slope of pressure settlement graph

b. Pressure corresponding to the settlement of 1.25 mm

c. Pressure corresponding to a pressure of 1.25 kg/cm^2

d. Pressure corresponding to the settlement of 1.50 mm

Ans. b

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30. The mix design for pavement concrete is based on the IES 2006

a. flexural strength
b. characteristic compressive strength
c. shear strength
d. bond strength

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31. Match List-I (Method of design for flexible pavement) with List-II (Principle) and select the correct answer using the codes given below the lists: IES 2006

List-I		List-II	
A	Group Index Method	1.	Semi-theoretical
B	CBR Method	2.	Quasi-rational
C	US Navy Method	3.	Empirical method using soil classification test
D	Asphalt Institute Method	4.	Empirical method using soil strength test

a. A3 B1 C4 D2   b. A2 B4 C1 D3   **c.** A3 B4 C1 D2   d. A2 B1 D4 D3

Ans. c

32. California Bearing Ratio (CBR) is a: IES 2005

a. Measure of soil strength

b. Method of soil identification

c. Measure to indicate the relative strengths of paving materials

d. Measure of shear strength under lateral confinement

Ans. c

34. Match List-I (Tests) with List-II (Properties) and select the correct answer using the codes given below the lists: IES 2003

List-I		List-II	
A	CBR test	1	Modulus of sub-grade reaction
B	Plate bearing test	2	Arbitrary soil strength
C	Tri-axial test	3	Exudation and expansion pressure
D	Stabilometer and Cohesionmeter test	4	Shear parameters

a. A1 B2 C3 D4 b. A2 B1 C3 D4 c. A1 B2 C4 D3 **d.** A2 B1 C4 D3

Ans. d

37. Modulus of sub-grade reaction using 30 cm diameter plate is obtained as 200 N/cm^3. The value of the same (in N/cm^3) using the standard plate will be IES 2001

a. 500 b. 200 c. 85 **d.** 80

Ans. d

Modulus of sub-grade reaction, K_1 = 200 N/cm^3

Diameter of the plate, D_1 = 30 cm

Correct modulus of sub grade reaction, K = ?

Standard diameter of the plate, D = 75 cm

$$K.D = K_1.D_1$$

$$K \times 75 = 200 \times 30 \Rightarrow K = 80\ N/cm^3$$

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40. In cement concrete pavements, tie bar are installed in IES 1999

a. expansion joints b. contraction joints c. warping joints **d.** longitudinal joints

Ans. d

41. If the load, warping and frictional stresses in a cement concrete slab are 210 N/mm^2, 290 N/mm^2 and 10 N/mm^2 respectively, the critical combination of stresses during summer mid-day is IES 1999

a. 290 N/mm^2 b. 390 N/mm^2 **c.** 490 N/mm^2 d. 590 N/mm^2

Ans. c

Load stress = 210 N/mm^2

Warping stress = 290 N/mm^2

Frictional stress = 10 N/mm^2

During summer midday, critical stress occurs at the bottom of edge slab when it tends to warp downwards.

Critical stress = Load stress + warping stress – frictional stress

= 210 + 290 – 10 = 490 N/mm^2

42. As per latest IRC guidelines for designing flexible pavement of CBR method, the load parameter required is IES 1999

a. number of commercial vehicles per day

b. cumulative standard axles in msa

c. equivalent single axle load

d. number of vehicles (all types) during design life

Ans. b

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44. The general requirement in constructing a reinforced concrete road is to place a single layer of reinforcement IES 1998

a. near the bottom of the slab
b. near the top of the slab
c. at the middle
d. equally distributed at the top and bottom

Ans. c

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47. If the CBR value obtained at 5 mm penetration is higher than that at 2.5 mm, then the test is repeated for checking, and if the check test reveals a similar trend, then the CRB value is to be reported as the IES 1997

a. mean of the values for 5 mm and 2.5 mm penetration

b. higher value minus the lower value

c. lower value corresponding to 2.5 mm penetration

d. higher value obtained at 5 mm penetration

Ans. d

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49. Effect of impact on the design of rigid pavements is accounted for by IES 1996

a. increasing the thickness as would be calculated with static wheel load

b. providing a base course

c. adopting a reduced flexural strength of concrete through a factor of safety

d. adopting an increased stress relative to that produced by static wheel load

Ans. a

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50. The plasticity index of the fraction passing 425 micron IS sieve in case of sub-base / base course should be IES 1996

a. less than 6 b. greater than 6 c. greater than 9 d. between 15 and 30

Ans. a

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52. Given that IES 1995

r = Radius of load distribution

E = Modulus of elasticity of concrete

K = Modulus of sub-grade reaction

μ = Poisson's ratio of concrete

h = Thickness of slab

P = Wheel load

The combination of parameters required for obtaining the radius of relative stiffness of cement concrete slab is

a. E, K, μ, r b. h, K, μ, r **c.** E, h, K, μ d. P, h, K, μ

Ans. c