GATE – CIVIL ENGINEERING

TRANSPORTATION ENGINEERING

Online Lecture: 7 (17.06.2020)

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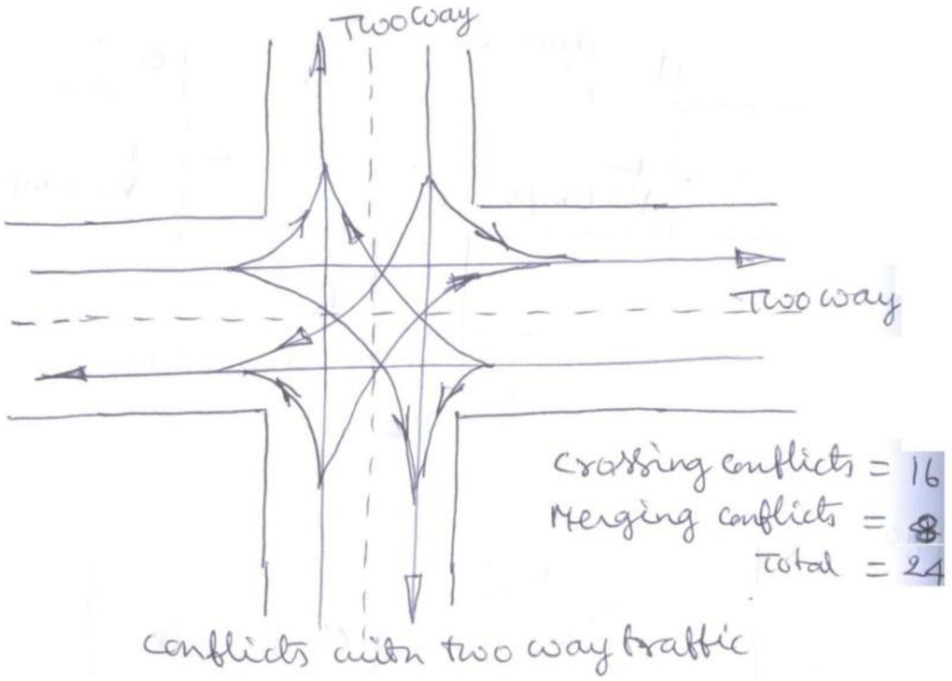
38. Two major roads with two lanes each are crossing in an urban area to form an un-controlled intersection. The number of conflict points when both roads are one-way is ‘X’ and when both roads are two-way is “Y”. The ratio of X to Y is

a. 0.25 b. 0.33 c. 0.50 d. 0.75 GATE 2012

38. a



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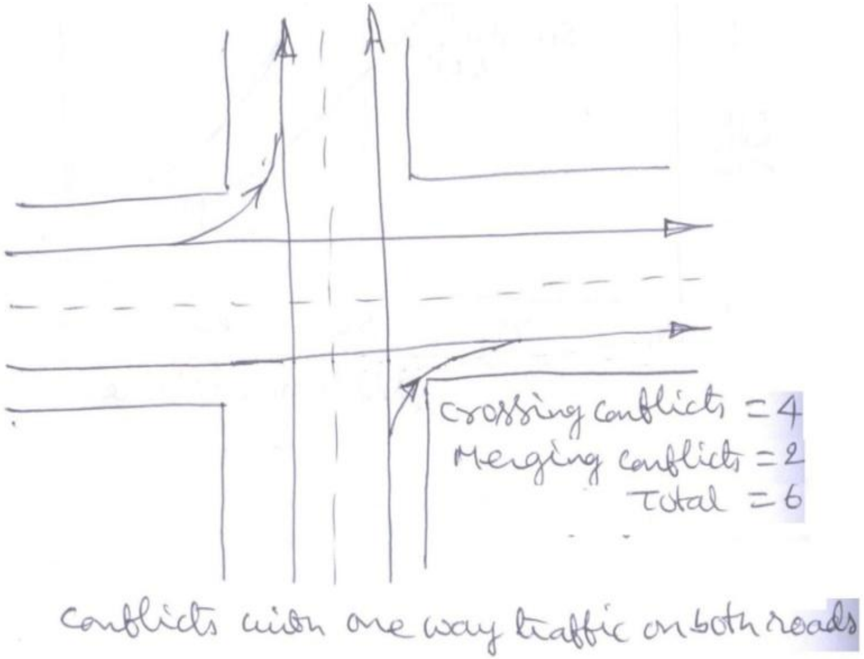

$$\frac{X}{Y} = \frac{6}{24} = 0.25$$

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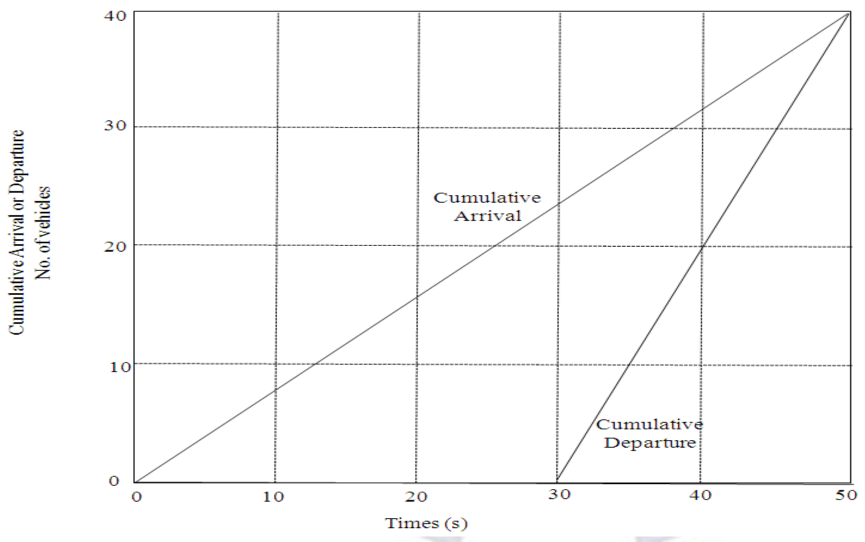
39. The cumulative arrival and departure curve of one cycle of an approach lane of a signalized intersection is shown in the adjoining figure. The cycle time is 50 s and the effective red time is 30 s and the effective green time is 20 s. What is the average delay ? GATE 2011



a. 15 s b. 25 s c. 35 s d. 45 s

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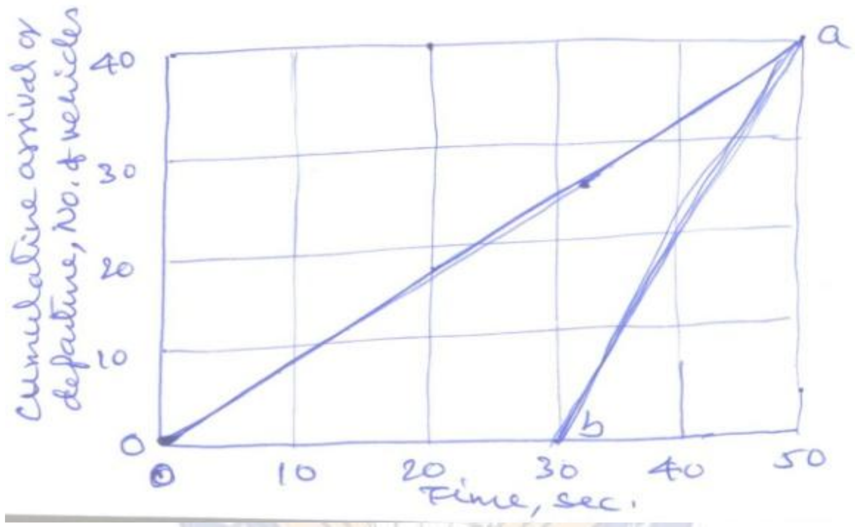
39. a



Since the cumulative arrival and cumulative departure of number of vehicles follow linear variation. Therefore, the average delay is the average of the time lag at the beginning and end of the green time.

$$\text{Average delay } = \frac{30+0}{2} = 15 \text{sec}$$

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40. If the jam density is given as k_j , and the free flow speed is given as u_f ,the maximum flow for a linear traffic speed density model is given by which of the following options? GATE 2011

a. $\frac{1}{4} k_j \times u_f$ b. $\frac{1}{3} k_j \times u_f$ c. $\frac{3}{5} k_j \times u_f$ d. $\frac{2}{3} k_j \times u_f$

40. a

k_j: Jam density

u_f: free flow speed

The maximum flow ($q_{\max}$) or the capacity of flow occurs when the speed is $\frac{u_f}{2}$ and density is $\frac{k_j}{2}$.

$$q_{\max} = \frac{u_f}{2} \cdot \frac{k_j}{2} = \frac{u_f \cdot k_j}{4}$$

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41. A vehicle negotiates a transition curve with uniform speed v. If the radius of the horizontal curve and the allowable jerk are R and J, respectively, the minimum length of the transition curve is GATE 2011

a. $R^3/(vJ)$ b. $J^3/(Rv)$ c. v^2R/J **d.** $v^3/(RJ)$

41. d

v : Speed of the vehicle

R : Radius of the horizontal curve

J : Allowable Jerk

L_s : Minimum length of transition curve

$$L_s = \frac{v^3}{JR}$$

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42. The probability that k number of vehicles arrive (i.e. cross a predefined line) in time t is given as $(\lambda t)^k e^{-\lambda t} / k!$, where λ is the average vehicle arrival rate. What is the probability that the time headway is greater than or equal to time t_1?

a. $\lambda e^{\lambda t_1}$ b. λe^{-t_1} c. $e^{\lambda t_1}$ **d.** $e^{-\lambda t_1}$ GATE 2011

42. d

The probability that k number of vehicles arrive in time t, $p(k) = \dfrac{e^{-\lambda t}(\lambda t)^k}{k!}$

where λ is the mean arrival rate.

The mean arrival rate is given as $\lambda = \dfrac{q}{3600}$, where q is the hourly flow rate.

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If the probability that zero vehicle arrived in the interval t_1 is given as $p(0)$, then the probability is same as the probability that the headway greater than or equal to t_1. Therefore,

$$p(x = \lambda t = 0) = e^{-\lambda t_1}$$

43. As per IRC:67-2001, a traffic sign indicating the speed limit on a road should be of

a. Circular shape with White Background and Red Border

b. Triangular shape with White Background and Red Border

c. Triangular shape with Red Background and White Border

d. Circular shape with Red Background and White Border GATE 2010

43. a

Traffic sign	Description
Speed limit	Circular shape with white background, red border and black numerals indicating the speed limit.
Warning signs	Triangular shape with white background, red border and black symbols.

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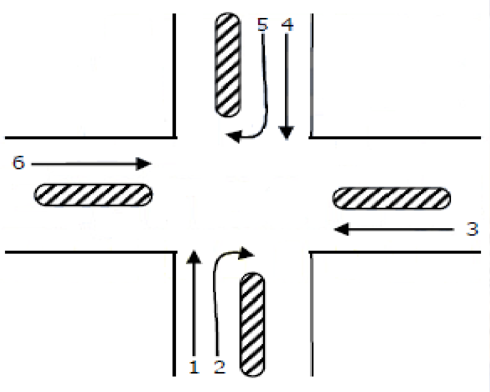
44. A three-phase traffic signal at an intersection is designed for flow shown in the figure below. There are six groups of flows identified by the numbers 1 through 6. Among these 1, 3, 4 and 6 are through flows and 2 and 5 are right turning. Which phasing scheme is not feasible ? GATE 2009



Combination choice	Phase I	Phase II	Phase III
P	1, 4	2, 5	3, 6
Q	1, 2	4, 5	3, 6
R	2, 5	1, 3	4, 6
S	1, 4	2, 6	3, 5

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a. P b. Q **c.** R d. S

44. c

Under combination choice R, in phase II, 1 and 3 cannot move simultaneously. Also in phase III, 4 and 6 cannot move simultaneously.

45. On a specific highway, the speed-density relationship follows the Greenberg's model [$v = v_f \ln(k_j / k)$], where v_f and k_j are the free flow speed and jam density respectively. When the highway is operating at capacity, the density obtained as per this model is GATE 2009

a. $e.k_j$ b. k_j c. $k_j / 2$ **d**. k_j / e

45. d

Greenberg's model for speed - density is $v = v_f \ln\left(\frac{k_j}{k}\right)$

v_f : Free flow speed

k_j : Jam density

v : Speed

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k : Traffic density

Capacity, C = Traffic density × speed = $k.v$

$$C = k.v_f \log_e\left(\frac{k_j}{k}\right)$$

For maximum capacity, $\frac{dC}{dk} = 0$

$$v_f\left[\log_e\left(\frac{k_j}{k}\right) + k.\frac{k}{k_j}.\left(\frac{-k_j}{k^2}\right)\right] = 0$$

$$\log_e\left(\frac{k_j}{k}\right) - 1 = 0 \quad ; \quad \log_e\left(\frac{k_j}{k}\right) = 1 \quad ; \quad e = \frac{k_j}{k} \quad ; \quad k = \frac{k_j}{e}$$

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46. A linear relationship is observed between speed and density on a certain section of a highway. The free flow speed is observed to be 80 km per hour and the jam density is estimated as 100 vehicles per km length. Based on the above relationship, the maximum flow expected on this section and the speed at the maximum flow will respectively be GATE 2008

a. 8000 vehicles per hour and 80 km per hour
b. 8000 vehicles per hour and 25 km per hour
c. 2000 vehicles per hour and 80 km per hour
d. 2000 vehicles per hour and 40 km per hour

46. d

Free flow speed, V_f = 80 km per hour

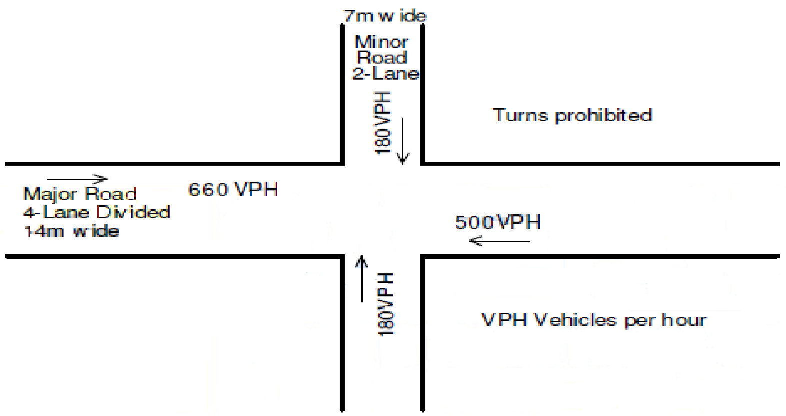
Jam density, k_j = 100 vehicles per km length.

The maximum flow occurs when speed becomes half of the free flow speed.

$$q_{\max} = \frac{V_f}{2} . \frac{k_j}{2} = \frac{80 \times 100}{4} = \text{ 2000 vehicles per hour}$$

Speed at $q_{\max}$, $\frac{V_f}{2} = \frac{80}{2}$ = 40 km per hour

47. Design parameters for a signalized intersection are shown in the figure below. The green time calculated for major and minor roads are 34s and 18s respectively. The critical lane volume on the major road changes to 440 vehicles per hour per lane and the critical lane volume on the minor road remains unchanged. The green time will GATE 2008



a. increase for the major road and remains same for the minor road

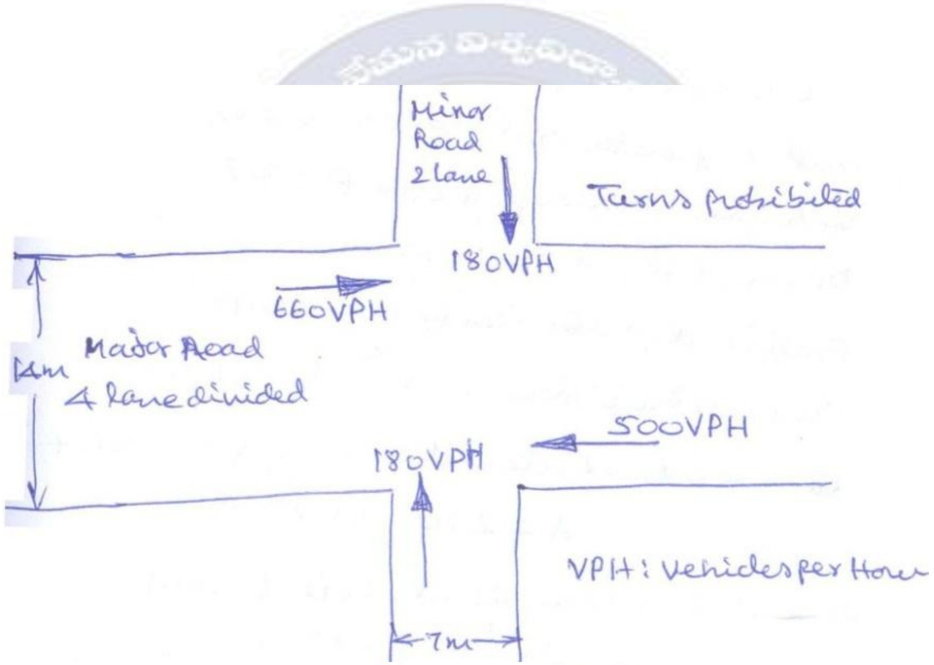
b. increase for the major road and decrease for the minor road

c. decrease for both the roads

d. remain unchanged for both the roads

47. a

If critical lane volume on major road is increased to 440 vehicles/hour/lane, the green time should be increased for major road and it remains same for minor road.



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48. A roundabout is provided with an average entry width of 8.4 m, width of weaving section as 14 m, and length of the weaving section between channelizing islands as 35 m the crossing traffic and total traffic on the weaving section are 1000 and 2000 PCU per hour respectively. The nearest rounded capacity of the roundabout in PCU per hour is GATE 2008

a. 3300 **b.** 3700 c. 4500 d. 5200

48. b

Average entry width, e = 8.4 m

Width of weaving section, W = 14 m

Length of the weaving section between channelizing islands, L = 35 m

Crossing traffic on the weaving section = 1000 PCU

Total traffic on the weaving section = 2000 PCU

$$\text{Proportion of the weaving traffic, } p = \frac{\text{Crossing traffic on the weaving section}}{\text{Total traffic on the weaving section}}$$

$$= \frac{1000}{2000} = 0.5$$

Practical capacity of the weaving section of a rotary,

$$Q_p = \frac{280W\left(1+\frac{e}{W}\right)\left(1-\frac{p}{3}\right)}{1+\frac{W}{L}} \qquad Q_p = \frac{280\times 14\left(1+\frac{8.4}{14}\right)\left(1-\frac{0.5}{3}\right)}{1+\frac{14}{35}}$$

$= 3733.3$ PCU per hour ≈ 3700 PCU per hour

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49. The shape of the STOP sign according to IRC : 67-2001 is GATE 2008

a. circular b. triangular **c.** octagonal d. rectangular

49. c

The shape of signs as per IRC : 67-2001 are

Shape	Sign
Circular	SPEED LIMIT (Vehicle control sign) NO ENTRY (Prohibitory sings)
Triangular	GIVE WAY
Octagonal	STOP
Rectangular	Informatory signs.

50. The capacities of “One-way 1.5 m wide sidewalk (persons per hour)” and “One-way 2-lane urban road (PCU per hour, with no frontage access, no standing vehicles and very little cross traffic)” are respectively. GATE 2008

a. 1200 and 2400 b. 1800 and 2000 c. 1200 and 1500 d. 2000 and 1200

50. a

The capacity of one-way 1.5 m wide sidewalk = 1200 persons per hour

The capacity of one way two lane urban road

Frontage access	No	Yes	Yes
Standing vehicles	No	No	Yes
Cross traffic	Very little	High capacity intersection	Heavy
Capacity, PCU per hour	2400	1500	1200

51. In signal design as per Indian Roads Congress specifications, if the sum of the ratio of normal flows to saturation flow of two directional traffic flow is 0.50 and the total lost time per cycle is 10 seconds, the optimum cycle length in seconds is

a. 100 b. 80 c. 60 **d.** 40 GATE 2007

51. d

Sum of the ratio of normal flows to saturation flow of two directional traffic flow, $Y = 0.5$

Total lost time per cycle, $L = 10$ seconds

Optimum signal cycle is given by

$$C_0 = \frac{1.5L+5}{1-Y} = \frac{1.5\times10+5}{1-0.5} = 40 \text{ sec}$$

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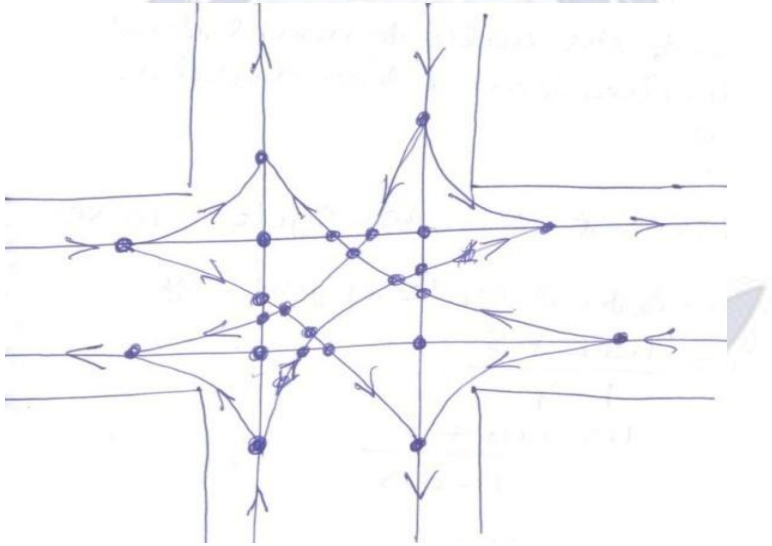
52. If a two-lane national highway and a two-lane state highway intersect at right angles, the number of potential conflict points at the intersection, assuming that both the roads are two-way is GATE 2007

a. 11 b. 17 **c.** 24 d. 32

52. c



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On a right angled road intersection with two way traffic, the total number of conflicting points are 24. This consists of 16 crossing conflicts which are the major conflict points. The merging and diverging conflicts are considered as minor conflicts, numbering 4 in each case.

Major conflicting points	:	16
Diverging conflicting points	:	4
Merging conflicting points	:	4
		24

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53. On an urban road, the free mean speed was measured as 70 kmph and the average spacing between the vehicles under jam condition as 7.0 m. The speed-flow-density equation is given by

$$U = U_{sf}\left[1 - \frac{k}{k_j}\right] \quad \text{and} \quad q = Uk$$

where U = space-mean speed (kmph); U_{sf} = free mean speed (kmph);
k = density (veh/km); k_j = jam density (veh/km); q
maximum flow (veh/hr) per lane for this condition is equal to GATE 2006

a. 2000 **b.** 2500 c. 3000 d. None of these

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53. b

The speed-flow-density equation is given by

$$U = U_{sf}\left[1 - \frac{k}{k_j}\right] \quad \text{and} \quad q = U.k$$

U : Space mean speed, kmph

U_{sf} : Free mean speed, kmph = 70 kmph

k : Density, vehicles/km

k_j : Jam density, Vehicles/km = $\dfrac{1000}{\text{average spacing between vehicles}} = \dfrac{1000}{7}$

q : Flow, Vehicles / hour

q_{max} : Maximum flow per lane, vehicles / hour

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$$q = U.k$$

$$= U_{sf}\left[1-\frac{k}{k_j}\right]k = U_{sf}\left[k-\frac{k^2}{k_j}\right]$$

For maximum traffic flow, $\frac{dq}{dk} = 0$

$$U_{sf}\left[1-\frac{2k}{k_j}\right] = 0 \quad ; \quad 1-\frac{2k}{k_j} = 0 \quad ; \quad k = \frac{k_j}{2}$$

$$q_{\max} = U_{sf}\left[\frac{k_j}{2} - \frac{k_j^2}{4}.\frac{1}{k_j}\right] = U_{sf}\left[\frac{k_j}{2} - \frac{k_j}{4}\right] = U_{sf}.\frac{k_j}{4}$$

$$= 70 \times \frac{1000}{7 \times 4} = 2500 \text{ vehicles/hour}$$

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54. For designing a 2-phase fixed type signal at an intersection having North-South and East-West road where only straight ahead traffic permitted, the following data is available.

Parameter Design Hour	North	South	East	West
Flow (PCU/hr)	1000	700	900	550
Saturation Flow (PCU/hr)	2500	2500	3000	3000

Total time lost per cycle is 12 seconds. The cycle length (seconds) as per webster's approach is GATE 2006

a. 67 **b.** 77 c. 87 d. 91

54. b

As per Webster's approach, the optimum signal cycle is given by

$$C_0 = \frac{1.5L + 5}{1 - Y}$$

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For N-S road and E-W road, the higher traffic volume will be taken.

$q_1 = 1000$ $\qquad$ $q_2 = 900$

$S_1 = 2500$ $\qquad$ $S_2 = 3000$

$$y_1 = \frac{q_1}{S_1} = \frac{1000}{2500} = 0.4 \qquad y_2 = \frac{q_2}{S_2} = \frac{900}{3000} = 0.3$$

$$Y = y_1 + y_2 = 0.4 + 0.3 = 0.7$$

L : Total lost time per cycle, sec

= 12 sec.

$$C_0 = \frac{1.5 \times 12 + 5}{1 - 0.7} = 76.67 \text{ sec} = 77 \text{ sec.}$$

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55. Name the traffic survey data which is plotted by means of “Desire lines”.

a. Accident
b. Classified volume
c. Origin and Destination
d. Speed and Delay

GATE 2006

55. c

Desire lines are graphical representation prepared in Origin and Destination Surveys. Desire lines are straight lines connecting the origin points with destinations, summarized into different area groups.

56. A single lane unidirectional highway has a design speed of 65 kmph. The perception-brake-reaction time of driver is 2.5 seconds and the average length of vehicles is 5 m. The coefficient of longitudinal friction of the pavement is 0.4. The capacity of this road in terms of 'vehicles per hour per lane' is GATE 2005

a. 1440 b. 750 **c.** 710 d. 680

56. c

Design speed, V = 65 kmph

Perception brake reaction time of driver, t = 2.5 sec

Average length of vehicle, L = 5m

The coefficient of longitudinal friction, f = 0.4

Capacity of road , $C = \dfrac{1000V}{S}$

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Space headway, $S = 0.278Vt + \frac{V^2}{254f} + L$

$$S = 0.278 \times 65 \times 2.5 + \frac{65^2}{254 \times 0.4} + 5$$

$$= 91.8 \text{ m}$$

$$C = \frac{1000 \times 65}{91.8} = 708.4$$

Vehicles per hour per lane = 710

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57. A transport company operates a scheduled daily truck service between city P and city Q. One-way journey time between these two cities is 85 hours. A minimum layover time of 5 hours is to be provided at each city. How many trucks are required to provide this service. GATE 2005

a. 4 b. 6 c. 7 **d.** 8

57. d

Layover time = 5 hours

Total journey time for one round trip = 85 + 85 + 5 = 175 hours

Minimum number of trucks required = $\frac{175}{24}$ =7.3 = 8 nos.

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58. Three new roads P,Q, and R are planned in a district. The data for these roads are given in the table below.

Road	Length (km)	Number of villages with population		
		Less than 2000	2000-5000	More than 5000
P	20	8	6	1
Q	28	19	8	4
R	12	7	5	2

Based on the principle of maximum utility, the order of priority for these three roads should be GATE 2004

a. P,Q,R b. Q,R,P c. R,P,Q **d.** R,Q,P

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58. d

Road	Length, km	Number of villages with population		
		Less than 2000	2000-5000	More than 5000
P	20	8	6	1
Q	28	19	8	4
R	12	7	5	2

Assuming the utility units as given below

Population	< 2000	2000 - 5000	> 5000
Unit	0.25	0.50	1.0

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Road	Length (m)	Total utility units	Utility per unit length	Priority
P	20	$8 \times 0.25 + 6 \times 0.5 + 1 \times 1 = 6$	$\frac{6}{20} = 0.3$	III
Q	28	$19 \times 0.25 + 8 \times 0.5 + 4 \times 1 = 12.75$	$\frac{12.75}{28} = 0.4553$	II
R	12	$7 \times 0.25 + 5 \times 0.5 + 2 \times 1 = 7.75$	$\frac{7.75}{12} = 0.645$	I

The order of priority of roads: R, Q, P

59. The road geometrics in India are designed for the GATE 2004

a. 98^{th} highest hourly traffic volume

b. 85^{th} highest hourly traffic volume

c. 50^{th} highest hourly traffic volume

d. 30^{th} highest hourly traffic volume

59. d

The road geometrics in India are designed for

i. 30^{th} highest hourly traffic volume

ii. 98^{th} percentile speed.

60. The speed and delay studies on a defined section of highway are conducted by

a. radar gun
b. traffic counters
c. moving car method
d. enoscope
GATE 2003

60. c

Speed and delay studies are useful in detecting the spots of congestion.

Methods to carry speed and delay study are:

i. Moving car or floating car method or riding check method
ii. License plate method
iii. Interview method
iv. Elevated observation
v. Photographic technique

Traffic counters are used for traffic volume study.

Enoscope is used for spot speed study.

Radar gun is used for counting the number of vehicles crossing a section of the road in a desired period.

61. The unit for coefficient of subgrade modulus is GATE 1997

a. kN/m^3 b. kN/m^2 c. kN/m d. kNm

61. a

The unit of coefficient of subgrade modulus is kN/m^3. Modulus of subgrade reaction is the pressure sustained for a plate settlement of 0.125 cm.

$$k = \frac{p}{\Delta} \ kN/m^2/m \quad \text{ie., } kN/m^3.$$

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62. The PCU (Passenger Car Unit) value for car on an urban road is GATE 1992

a. 0.5 **b.** 1.0 c. 3.0 d. 4.0

62. b

Equivalency factors suggested by IRC:

S.No.	Vehicle class	PCU
1.	Passenger car, tempo, Auto rickshaw, Agricultural tractor.	1.0
2.	Bus, truck, Agricultural tractor-trailer unit	3.0
3.	Motor cycle, scooter, pedal cycle	0.5
4.	Cycle rickshaw	1.5
5.	Horse drawn vehicles	4.0
6.	Small bullock cart and hand cart	6.0
7.	Large bullock cart	8.0

63. Desire lines are drawn based on GATE 1992

a. spot speed studies
b. traffic volume studies
c. accident studies
d. origin and destination studies

63. d

The origin and destination studies provide the basic data for determining the designed directions of flow. Based on these data desire lines are drawn.

64. Moving car observer method is a procedure GATE 1991

a. to find the traffic flow of traffic stream

b. to estimate the traffic capacity of a road section

c. to carry out origin destination studies

d. to identify accident prone locations on highway

64. b

Mathematical models	to find the traffic flow or traffic stream
Moving car method	to estimate the traffic capacity of a road section
Automatic Number Plate Recognition method Road Side Interview method	to carryout origin and destination studies
Location files	to identify accident prone locations on highway

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15.4 DESIGN OF FLEXIBLE AND RIGID PAVEMENTS

- The pavement carries the wheel loads and transfer the load stresses through a wider areas on the soil sub grade below.
- The reduction in the wheel load stress due to the pavement depends on its thickness and the characteristics of the pavement layers.
- A pavement layer is considered more effective, if it is able to distribute the wheel load stress through a larger area per unit depth of the layer.
- Types of pavements i. Flexible Pavements, and ii. Rigid Pavements.

Flexible pavement

Rigid pavement

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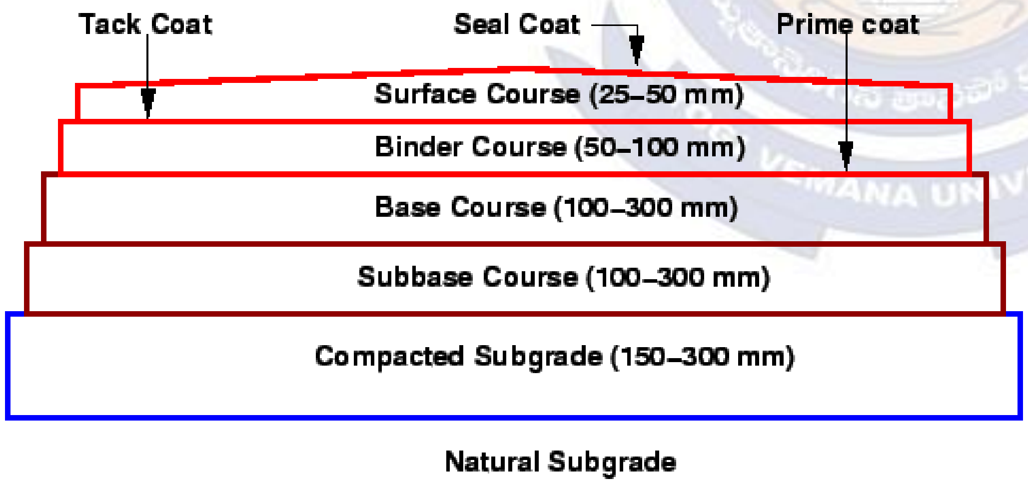
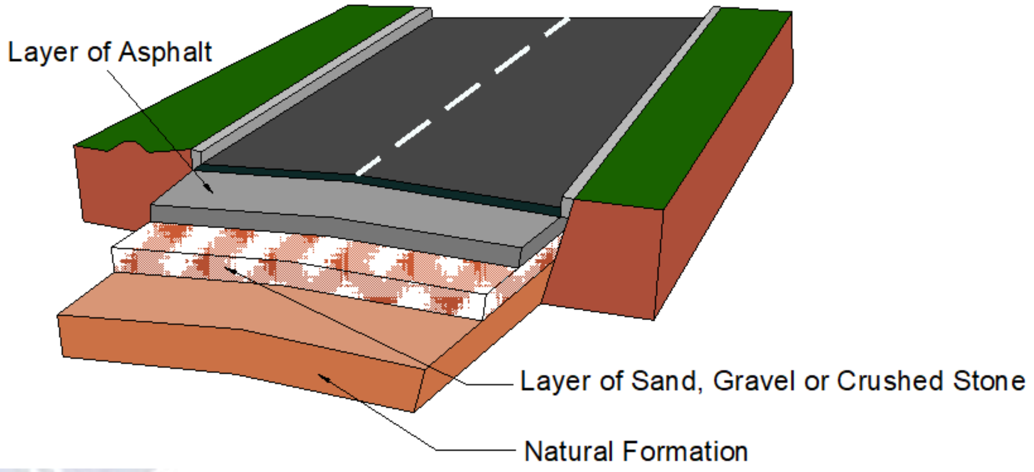
Flexible Pavements:

- have low or negligible flexural strength.
- Flexible in their structural action under the load.
- Flexible pavements layers reflect the deformation of the lower layers on the surface of the layer.
- Components are a. Soil sub grade
  b. Sub-base course.
  c. Base course.
  d. Surface course.





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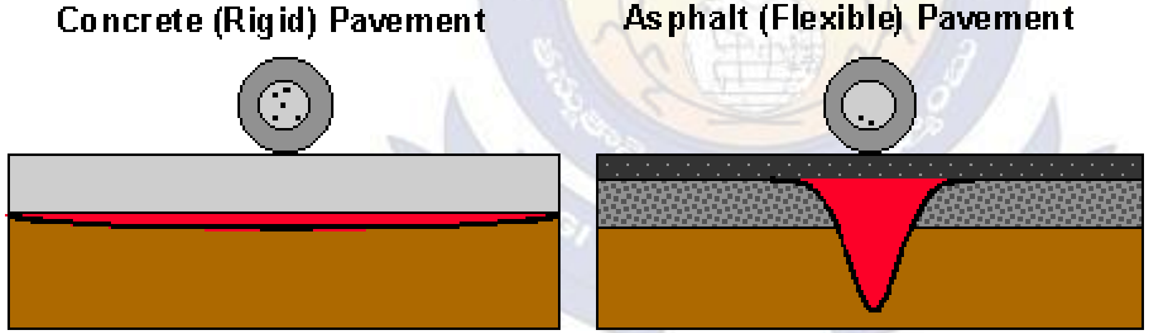
- Transmits the vertical or compressive stresses to the lower layers by grain to grain transfer through the point of contact in the granular structure.
- Load spreading ability of the layer depends on the type of the material and the mix design factors.
- The stresses get decreased in lower layers.
- Stress distributes to a larger area in the shape of truncated cone.
- Consists of number of layers, the top layer has to be the strongest.
- Rigid Pavement Flexible Pavement



Concrete acts more like a bridge over the subgrade. Inch-for-inch much less pressure is placed on materials below concrete than asphalt pavements.

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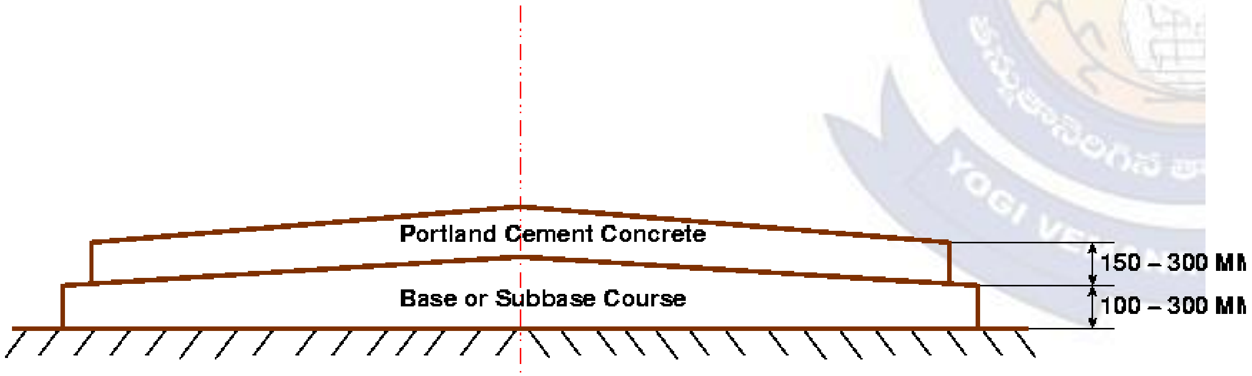
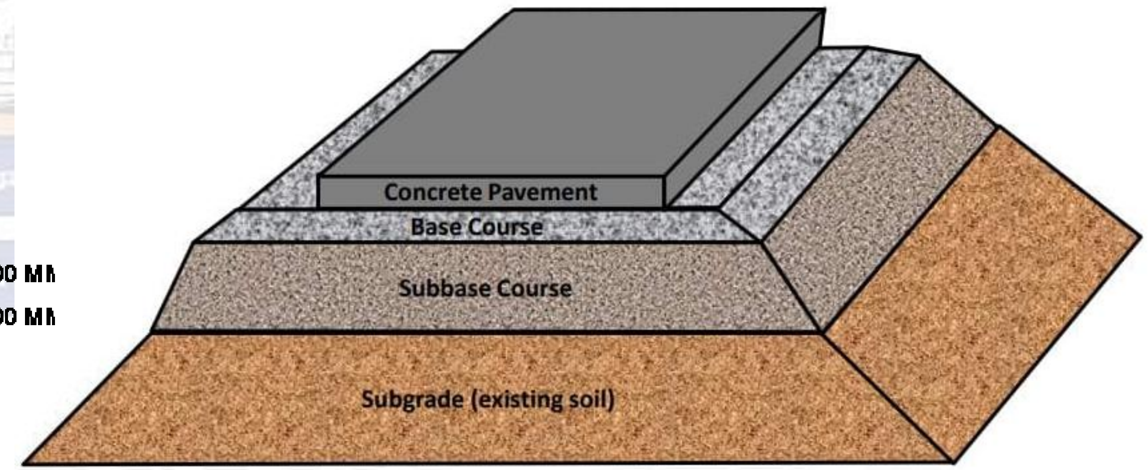
Rigid pavements:

- Possess flexural strength or flexural rigidity.
- Stresses are not transferred from grain to grain to the lower layers.
- Made of PCC, RCC or PSC.
- Flexural stress in plain cement concrete slabs is 4 N/mm^2 or 40 kg/cm^2
- The rigid pavement has slab action and transmits the wheel load stresses through a wider area below.





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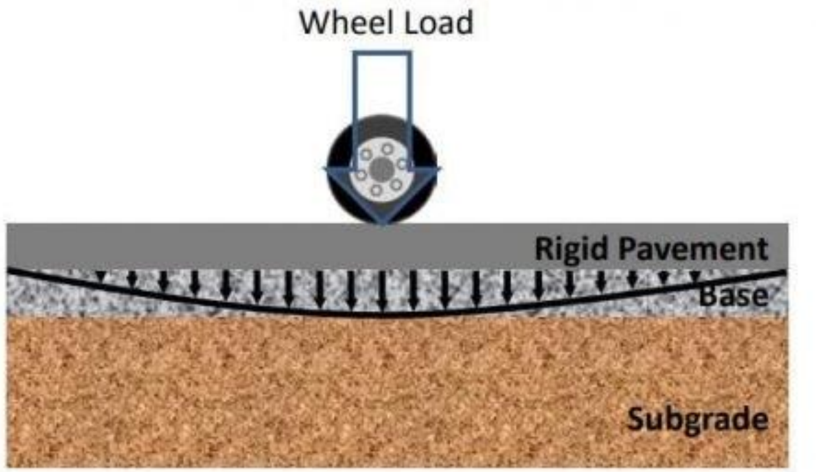
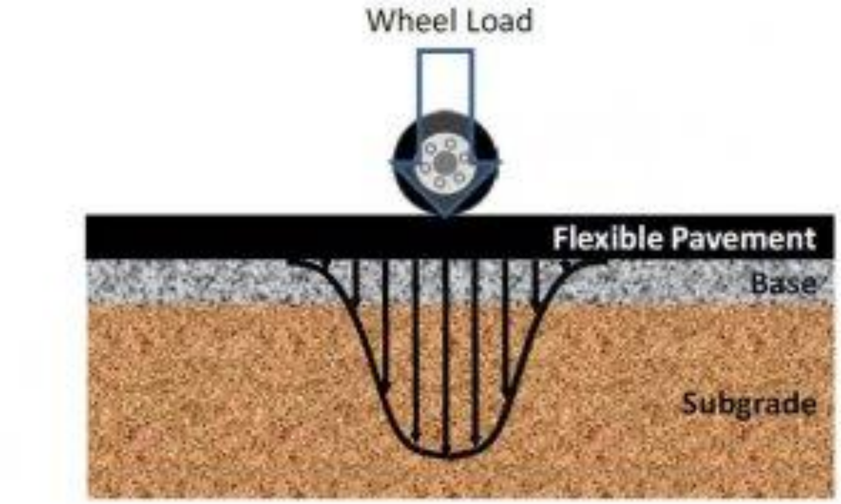
- Rigid pavements - critical condition of stress is the maximum flexural stress due to wheel load and the temperature changes.
- Flexible pavements - critical condition is the distribution of compressive stresses.
- Rigid pavement does not get deformed to the shape of the lower surface.
- Cement concrete pavement slab can serve as a wearing surface as well as an effective base course.
- Rigid pavements are usually designed and the stresses are analyzed using the elastic theory, assuming the pavement as an elastic plate resting over elastic or a viscous foundation.





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Semi rigid pavements:

- usually the bounded materials like pozzalonic concrete (lime-flyash-aggregate mix), lean cement concrete or soil cement in the base course or sub base course layer.
- Low resistance to impact and abrasion
- usually provided with flexible pavement surface course.

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Functions of pavement components

- Soil sub grade is a layer of natural soil prepared to receive the layers of pavement materials placed over it.
- Common strength tests for the evaluation of soil sub grade are

  California Bearing Ratio test

  California Resistance Value test.

  Triaxial compression test

  Plate bearing test.
- California bearing ratio test is a penetration test, evolved for the empirical method of flexible pavement design.
- California resistance value test is used in an empirical method of flexible pavement design.
- Triaxial is considered as most important soil strength test.
  - Not very commonly used in structural design of pavements because only a few theoretical method make use of the results.

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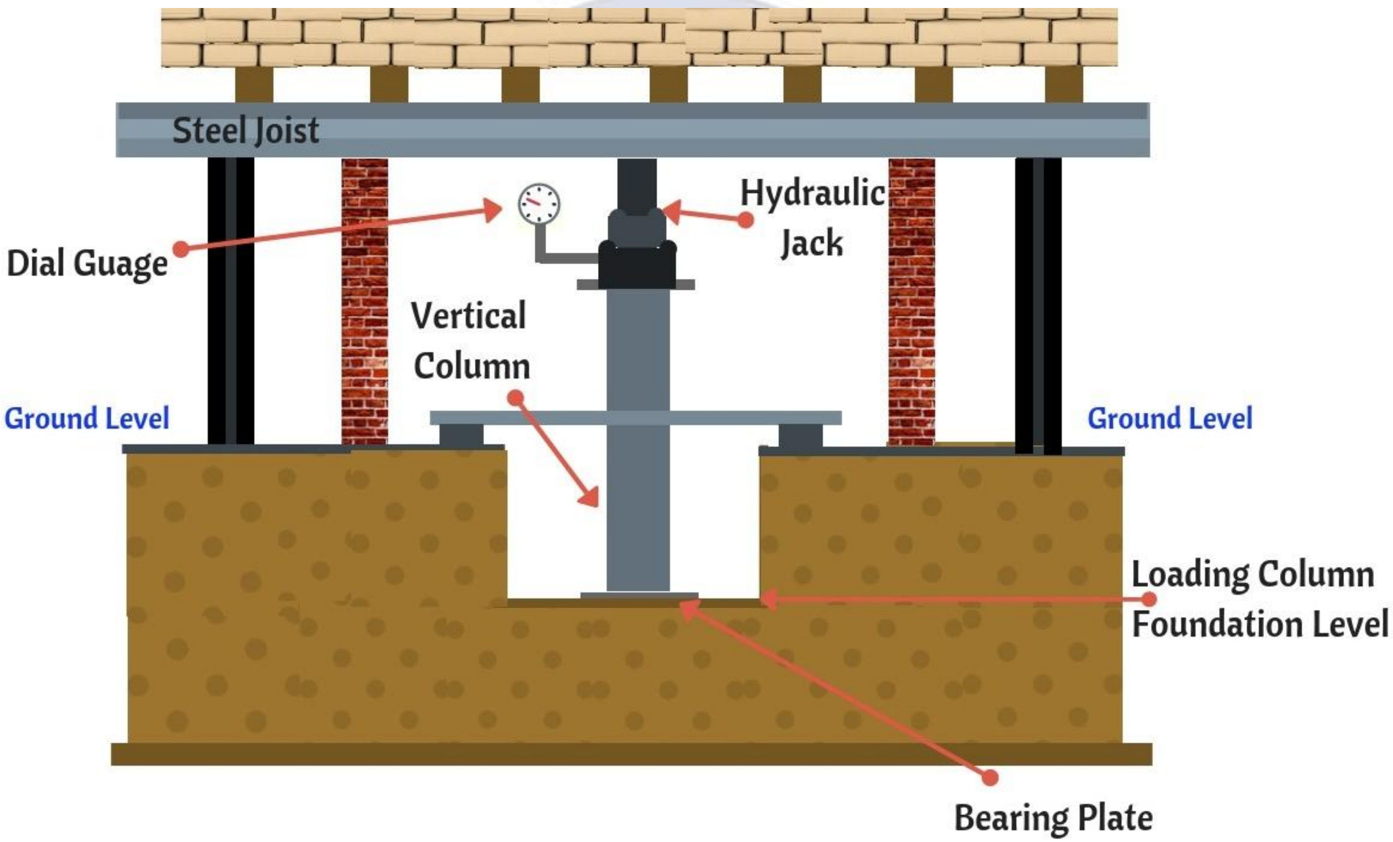
Plate bearing test

- to evaluate the load supporting capacity of supporting power of the pavement layer.
- used for determining the elastic modulus of sub grade and the pavement layers.
- used for the determination of modulus of sub grade reaction.



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Base course and sub base courses

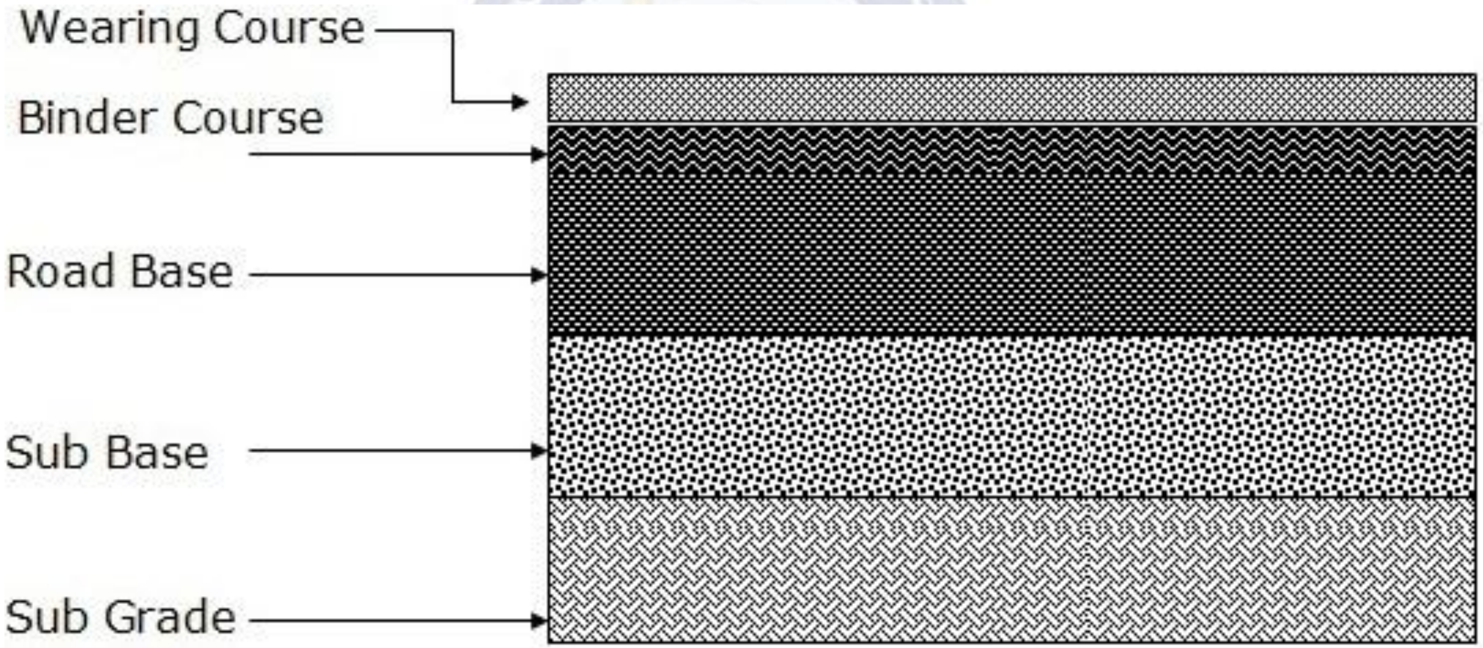
- used under flexible pavements to improve the load supporting capacity by distributing the load through finite thickness.
- Base courses are used under rigid pavement for
  - i. Preventing pumping
  - ii. Protecting the subgrade against frost action.
- to provide stress transmitting medium to spread the surface wheel loads in such manner as to prevent shear and consolidation deformations.

Sub base or base course layers

- evaluated by plate bearing, CBR or stabilometer test.

Wearing course

- to give a smooth riding surface.
- Bituminous surfacing in flexible pavement.
- Cement concrete in rigid pavement
- Plate bearing test and Benkelman beam test are used for evaluating the wearing course.



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Design factors

Pavement design consists of

i. Mix design of material in each component layer.

ii. Thickness design of the pavement and component layers.

Factors to be considered for the design of pavements are

a. Design wheel load.

b. Sub grade soil.

c. Climatic factors

d. Pavement component materials

e. Environmental factors.

f. Special factors.

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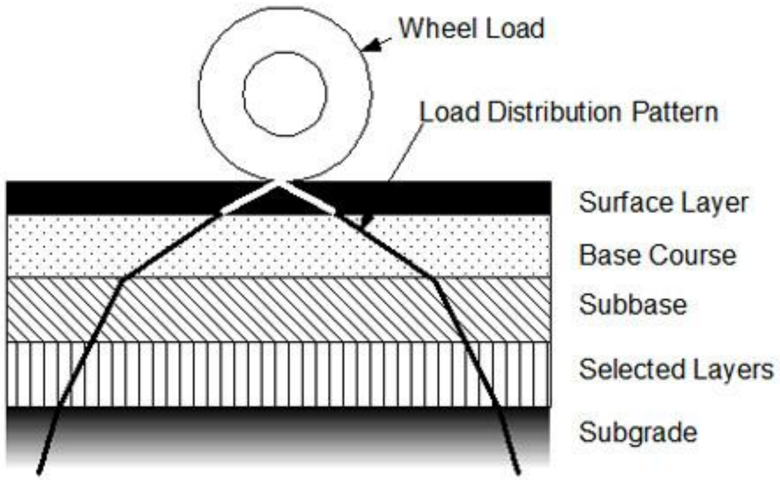
- The thickness of pavement primarily depends on the design wheel load.
- As the speed increases, the rate of application of the stress is also increased resulting in a reduction in the pavement deformation.
- On uneven pavements, impact increases with speed.
- The pavement performance depends greater on the sub grade soil properties and the drainage.
- Rainfall affects the moisture conditions in the sub grade and the pavement layers.
- The stress distribution characteristic of the pavement component layers depends on characteristics of the materials used.
- Wrapping stresses in rigid pavements depend on the daily variations in the temperature in the region and in the maximum difference in temperature between the top and bottom of the pavement slab.

Design wheel load

- Wheel load factors to be considered in pavement design are
  - a. Maximum wheel load
  - b. Contact pressure
  - c. Dual or multiple wheel loads and equivalent single wheel load.
  - d. Repletion of loads
- For highways the maximum axle load is 8170 kg with a maximum Equivalent Single Wheel Load (ESWL) of 4085 kg.
- Vertical stress under a u.d.l based on Boussinesq' theory is given by



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$$\sigma_z = p\left[1 - \frac{z^3}{\left(a^2 + z^2\right)^{3/2}}\right]$$

σ_z : Vertical stress at depth z

p : surface pressure

z : depth at which σ_z is computed

a : radius of loaded area.

The stresses on the pavement surface under the steel tyred wheels of bullock carts are very high.

$$\text{Contact pressure} = \frac{\text{load on wheel}}{\text{contact area or area of imprint}}$$

Tyre pressure or inflation pressure are same.

Contact pressure > tyre pressure (when tyre pressure < 7 kg/cm^2)

Contact pressure < tyre pressure (when tyre pressure > 7 kg/cm^2)

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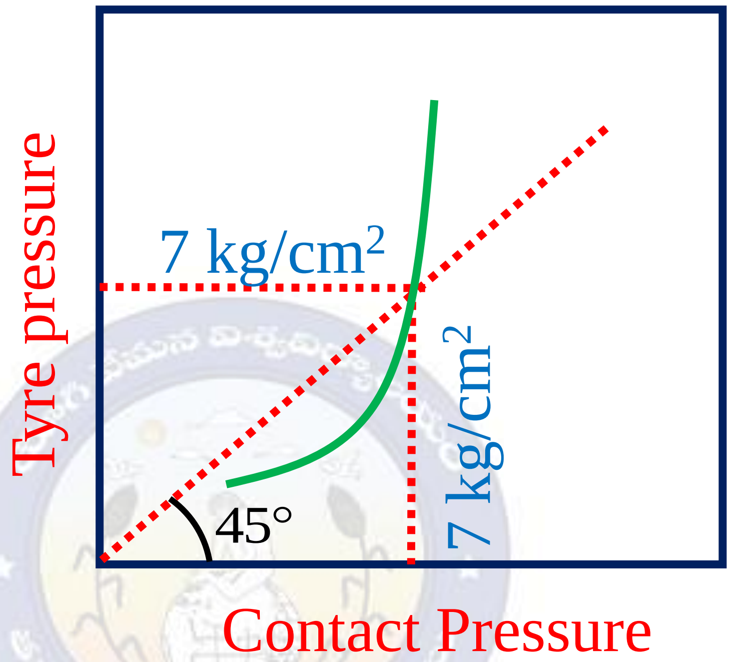

$$\text{Rigidity factor} = \frac{\text{Contact pressure}}{\text{Tyre pressure}}$$

$= 1.0$ tyre pressure $= 7\ kg/cm^2$

> 1.0 tyre pressure $< 7\ kg/cm^2$

< 1.0 tyre pressure $> 7\ kg/cm^2$