Subject Name: TRANSPORTATION ENGINEERING

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Unit-I: (Highway Development and Planning)

Important points / Definitions:

- **Highway engineering** is an **engineering** discipline branching from civil **engineering** that involves the planning, design, construction, operation, and maintenance of roads, bridges, and tunnels to ensure safe and effective transportation of people and goods. Standards of highway engineering are continuously being improved.
- **The alignment** is the route of the road, defined as a series of horizontal tangents and curves. The profile is the vertical aspect of the road, including crest and sag curves, and the straight grade lines connecting them.
- **Engineering surveying** as those activities involved in the planning and execution of surveys for the development, design, construction, operation and maintenance of civil and other engineered projects.
- **The National Highways** network of India is a network of trunk roads that is owned by the Ministry of Road Transport and Highways. These **highways** as of April 2019 measure over 142,126 km (88,313 mi). The Indian government has vowed to double the highway length from 96,000 to 2,00,000 km.
- **Preliminary survey Objective of preliminary survey are:** To survey the various alternative alignments proposed after the reconnaissance and to collect all the necessary physical information and detail of topography, drainage and soil.
- The **road network** is the system of interconnected roads designed to accommodate wheeled road going vehicles and pedestrian traffic**.**
- The **Road Formation** is the surface of finished earthworks on which a **road** pavement is constructed.
- **Purpose of Roads** make a crucial contribution to economic development and growth and bring important social benefits. They are of vital importance in order to make a nation grow and develop. In addition, providing access to employment, social, health and education services makes a road network crucial in fighting against poverty.
- **Road widening** is required to keep up with the phenomenal increase in vehicular population in Bengaluru and resultant traffic congestion thereof. Road widening also helps to improve facilities to pedestrians and cyclists, to achieve fast movement of traffic and thereby reduce pollution.

- **Road maintenance** involves remedying defects such as potholes that occur in the carriageway from time to time (corrective maintenance) and providing treatments such as crack sealing which will slow the rate of deterioration (preventative maintenance).
- **Road transport** means transportation of goods and personnel from one place to the other on roads. ... Sometimes road transport is the only way for carrying goods and people to and from rural areas which are not catered to by rail, water or air transport.
- **Road Patterns** The various **road patterns** may be classified as:
- •Rectangular or Block **pattern** •Radial or star and block pattern
- •Radial or star and circular **pattern**
- •Radial or star and grid **pattern**
- •Hexagonal **pattern**
- •Minimum travel pattern. Rectangular or block **pattern** Central Business Area Main **road** Junction.

SHORT ANSWER QUESTIONS

1**.** What is the Necessity for highway planning in our country?

2**.** Write about Jayakar Committee and its Recommendations?

3. What do you understand by obligatory points?

4. Explain the classification of Roads as per Nagpur road plan?

5. What are the main objectives of preliminary survey?

6. What are the various features of express ways?

7. Write about the classification of urban roads?

8. What are the general methods for classification of roads?

9. What are the disadvantages of improper road alignment?

10. What is highway alignment?

LONG ANSWER QUESTIONS

1. Explain the classification of roads?

2. Discuss the basic requirements of an ideal alignment?

3. Explain the classification of road patterns with neat sketches?

4. What are the factors controlling highway alignment?

5. Explain the salient features of second twenty year road plan?

6. Explain in detail regarding Map study in engineering surveys?

7. Discuss the necessity of realignment in a highway project?

8. Explain the stages of engineering surveys for highway location?

9. Discuss in detail about highway project report?

10. Explain the significance of central road research institute?

CHOOSE THE CORRECT ANSWER

1. First 20-year plan has a target road length of ……….

  A. 16 km per 50 sq.km

  B. 16 km per 100 sq.km

  C. 32 km per 50 sq.km

  D. 32 km per 100 sq.km

2. **Indian road congress was formed in…….**

  A. 1995

  B. 1935

  C. 1934

  D. 1936

3. Central Road Research Institute (CRRI) was started in the year……..

  A. 1950
  B. 1943
  C. 1960
  D. 1961

4. W.B.M. Road are also known as………
  A. Low cost roads
  B. Metalled roads
  C. Modern roads

    D. None of the above

5. The design speed of NH&SH on plain terrain with general cross slope upto 10% is….
A. 80 kmph

B. 70 kmph

C. 60 kmph

D. 100 kmph

6. National highway act was formed in…….

A. 1973

B. 1985

C. 1974

D. 1975

7. Highway Research Board was formed in……..

 A. 1976

B. 1978

C.1975

 D. 1974

8. National Transport Policy Committee was formed in…….

 A. 1950

 B. 1948

 C.1935

 D.1943

9. The most accessible road is……….
    A. National highway
    B. State highway
    C. Major District road
    D. Village road

10. **Approximate length of National highway in India is……….**
   A. 1000 km
   B. 5000 km
   C.10000 km
   D.50000 km

11. Density of road in India is nearly…………**.(1 km/sq.km)**

12. Period of second twenty year road plan is**…….(1961-1981)**

13. Earthen road and travel roads are also known as**…….(Low cost road)**

14. The layout of the centre line of the highway on the ground is called the…..(**Alignment**)

Unit-II: (Highway Geometric Design)

Important points / Definitions:

1. **Geometric** is something associated with **geometry**, or the use of straight lines and shapes. An example of **geometric** is an **art** piece made from rectangles, squares and circles.
2. **Objective of geometric design** is to produce a highway with safe, efficient, and economic traffic operations while maintaining esthetic and environmental quality. Geometric design is influenced by the vehicle, driver, and traffic characteristics.
3. **Design speed** is a tool used to determine geometric features of a new road during road design. Contrary to the word's implication, a road's design speed is not necessarily its maximum safe speed*;* that can be higher or lower.
4. **Right of way:** The land area acquired along the highway alignment, for the construction and development of a road is called Right of way.
5. **Carriage way**: The road way portion constructed for the movement of the vehicle, traffic is called carriage way or pavement or crust.
6. **Shoulder:** The road way portion comprising between the outer edges of the pavement and the edges of the top surface of the embankment of the inner edges of the side drains in cutting is known as Shoulder.
7. **Stopping sight distance** is one of several types of sight distance used in road design. It is a near worst-case distance a vehicle driver needs to be able to see in order to have room to *stop* before colliding with something in the roadway, such as a pedestrian in a crosswalk, a stopped vehicle, or road debris.
8. **Intermediate sight distance:** Intermediate sight distance (ISD) is **defined** as twice SSD. Overtaking **sight distance** (OSD) for safe overtaking operation. Head light **sight distance** is the **distance** visible to a driver during night driving under the illumination of head lights. Safe **sight distance** to enter into an intersection
9. **Overtaking sight distance** is the minimum **distance** open to the vision of the driver of a vehicle intending to **overtake** the slow vehicle ahead safely against the traffic in the opposite direction.
10. **Reaction time** of a driver is the **time** taken from the instant the object is visible to the driver to the instant when the brakes are applied. The **total reaction time** may be split

up into four components based on PIEV theory. ... For example, IRC suggests a **reaction time** of 2.5 secs.

SHORT ANSWER QUESTIONS

1. What is Camber and explain its uses in detail?

2. Write about kerbs and mention various types of kerbs?

3. What do you understand by right of way?

4. Explain head light sight distance and stopping sight distance?

5. What do you understand by lag distance in the analysis of stopping sight distance?

6. Explain the concept of braking distance along with the formulae?

7. What do you understand by overtaking zones?

8. What do you understand by mechanical widening?

9. Explain set back distance and mention various factors influencing set back distance?

10. What is gradient and mention types of gradients?

LONG ANSWER QUESTIONS

1. Explain the concept of total reaction time in stopping sight distance?

2. What are the factors controlling geometric design?

3. Write about Design of Transition curves in detail? Explain the concept of shift?

4. Calculate the safe stopping sight distance for design speed of 50 kmph for two way traffic on a
   Two way line?

5. Derive the expression for super elevation and explain with the help of neat sketches?

6. What is skid resistance and what are the factors on which it depends?

7. Explain different types of gradients that can be provided on highway alignment?

8. Calculate the safe stopping sight distance for design speed of 100 kmph for two way traffic on a single lane road?

9. Explain the concept of PIEV theory in detail?

10. Derive an expression for stopping sight distance with the help of neat sketches?

11. Derive an expression for overtaking sight distance with the help of neat sketches?

12. Define skid resistance? What are the factors affecting it?

13. Explain the factors on which overtaking sight distance depends?

14. The speeds of overtaking and overtaken vehicles are 80 and 60 kmph respectively. If the acceleration of the overtaking vehicle is 2.5Kmph per second, Calculate the
Safe Overtaking sight distance for two way traffic?

15. Explain the different types of Transition Curves?

16. While aligning a highway in a built up area, it was necessary to provide a horizontal circular curve of radius 325m. Design the following geometric features
   i) Super elevation
   ii) Extra widening of pavement
  iii) Length of transition curve
   Data available are Design speed 65kmph, Length of wheel base of largest track 6m, pavement width10.5m

17. There is a horizontal highway curve of radius 400m and length 200m on this highway. Compute the set-back distance required from the centre line on the inner side of the curve so as to provide for
   i) Stopping sight distance of 90m
   ii) safe overtaking sight distance of 300m.
The distance between the centre lines of the road end the inner line is 1.9m.

18. A vertical summit curve is formed at the intersection of two gradients,+3.0 and -5.0 percent. Design the length of summit curve to provide a stopping sight distance for a design speed of 80kmph.Assume other data.

19. An ascending gradient of 1 in100 meets a descending gradient of 1 in 120. A summit curve is to be designed for a speed of 80kmph so as to have an overtaking sight distance of 470m.

20. A valley curve is formed descending gradient of 1 in 25 meeting an ascending gradient of 1 in30. Design the length of valley curve to fulfil both comfort condition and head light sight distance requirements for design speed of 80kmph.Assume allowable rate of change of centrifugal acceleration C=0.6m/sec^3

CHOOSE THE CORRECT ANSWER

1. Reaction time of a driver is…….
   A. Same for all speeds
   B. Increases with increase speed
   C. Decreases with increase speed
   D. None of the above
2. Total reaction time of a driver does not depend upon……..
   A. Perception time
   B. Brake reaction time
   C. Condition of mind of the driver

D. Speed of vehicle

3. For a design speed of 80 km/hr, the minimum stopping sight distance for moving vehicle on a roadway is……..
   A. 80 m
   B. 120 m
   C. 150 m
   D. 200 m

4. Design speed is 80 kmph, reaction time is 2.5 sec, longitudinal friction is 0.4 and lateral friction is. Then sight distance in m is……..
   A. 49.6 m
   B. 118.46 m
   C. 123.8 m
   D. 189.5 m

5. Design coefficient of friction (f) for stopping distance lies between……
   A. 0.2 to 0.35
   B. 0.4 to 0.35
   C. 0.1 to 1.0
   D. 1.4 to 1.35

6. The time taken to perceive an object or situation is……….
   A. Volition
   B. Emotion
   C. Perception
   D. Intellection

7. The OSD is maximum for the following…….
   A. Single lane one way traffic
   B. Single lane two way traffic
   C. Multilane one way traffic
   D. Multilane two way traffic

8. The height of the driver above road surface as per IRC is…….

   A. **1.2 m**
   B. 1.5 m
   C. 0.75 m
   D. 1.4 m

9. The maximum length of rigid axle base as per IRC is……..
   A. 6.1 m
   B. 2.6 m
   C. 2.44 m
   D. 1.4 m

10. The maximum super-elevation for hill road should not exceed…….
    A. 0.005
    B. 0.050
    C. 0.8
    D. 0.1

11. The basic aspect on which every geometric design element of a road is dependent is………..(**Design Speed**)

12. The recommended lateral coefficient of friction by IRC for horizontal curve design is…………**(0.15)**
13. The pavement surface condition is commonly measured by using an equipment called……….**(Bump Intergrator)**
14. The distance travelled by the vehicle during the total reaction time is known as……….**(Lag distance)**
15. The absolute minimum radius for safe operation for a speed of 100 kmph is………**(357 m)**

Unit-III: TRAFFIC ENGINEERING AND REGULATION

Important points / Definitions:

1. **Traffic engineering**: It is defined as that phase of highway engineering which deals with planning and design of highway and with traffic operation there on for the safe, convenient and economic transportation of persons and goods.
2. **Traffic Volume:** Study. ... Volume Study θTraffic volume is defined as the number of vehicles crossing a section of road per unit time at any selected period.
3. **Speed:** It is defined as the distance(s) that is covered by a vehicle in specific time (t). **Speed** is the most critical aspect of the geometric design – the roads are designed according to the speed and the cost of any highway project is dependent on the speed. ... Speed is not consistent.
4. **Density:** It is the third fundamental traffic flow characteristic. It is an important characteristic that engineers can use in assessing traffic performance from the point of view of users and system operators. ... We define traffic density as the number of vehicles occupying a unit length of roadway.
5. **Parking**: It is defined as the ratio of number of bays occupied in a time duration to the total space available. It gives an aggregate measure of how effectively the parking space is utilized.
6. **Accident studies**: study of accident occurrence at a particular road or location or zone of study for a long period of time it is possible to predict with reasonable accuracy the probability of accident occurrence per day or relative safety of different classes of road user in that location.
7. **Objectives of accident studies:** To evaluate existing design. To compute the financial losses incurred. To support the proposed design and provide economic justification to the improvement suggested by the traffic engineer. To carry out before and after studies and to demonstrate the improvement in the problem.
8. **Collision diagrams** are used to display and identify similar accident patterns. They provide information on the type and number of accidents; including conditions such as time of day, day of week, climatic conditions, pavement conditions, and other information critical to determining the causes of safety problems.
9. **Traffic signs:** Traffic signs are means for exercising control on or passing information to the road users. They may be regulatory, warning, or informative.
10. **Traffic Signals**: Traffic control signals are devices placed along, beside, or above a roadway to guide, warn, and regulate the flow of traffic, which includes motor vehicles, motorcycles, bicycles, pedestrians, and other road users. RED—A red signal light means STOP.

SHORT ANSWER QUESTIONS

1. What is meant by Traffic Density in traffic engineering?

2. How the traffic volume data is collected and presented in traffic engineering?

3. Write in detail about the need for spot speed studies?

4. What is the need for road markings?

5. Show various types of traffic signs with neat sketches.

6. List out various measures that may be taken to prevent accidents?

7. What is origin and destination data and why do we do these studies?

8. What are the different types of traffic signal systems?

9. Describe various causes for road accidents?

10. Define On street and off street parking?

LONG ANSWER QUESTIONS

1. Explain the procedure for conducting spot speed studies. How do you analyze the Spot speed data?

2. Explain the objectives of traffic volume study and traffic volume count methods?

3. Describe in detail about parking studies?

4. Distinguish between On street and Off street parking?

5. What are the enforcement measures to reduce accident rates?

6. Write about traffic volume studies and explain how the data is collected and presented in traffic engineering?

7. Explain the design procedure of Traffic signals according to Webster method?

8. Explain various types of traffic signal systems?

9. What are the engineering measures to reduce accident rates?

10. Explain various types of traffic signal systems?

11. Explain the design procedure of Traffic signals

According to Webster method?

12. Describe various types of traffic signs used in traffic control and regulation giving at least two examples for each type. Support your answer with suitable sketches and Specifications for the signs?

13. Spot speed studies were carried out at a certain stretch of a highway and the consolidated data collected are given below.

Speed ranges, Kmph	No. of vehicles observed	Speed ranges, Kmph	No. of vehicles observed
0-10	12	50-60	225
10-20	18	60-70	119
20-30	68	70-80	43
30-40	89	80-90	33
40-50	204	90-100	9

Determine
   i)   the upper and lower values or speed limits for regulation of mixed traffic flow and
   ii)   the design speed for checking the geometric design elements of the highway

14. The consolidated data collected from speed and delay studies by floating car method on a stretch of urban road of length 3.5Km, running North-South are given below. Determine the average values of volume, journey speed and running speed of the traffic stream along either direction.

Trip No.	Direction of trip	Journey time Min.sec	Total stopped delay Min.sec	No. of vehicles overtaking	No. of vehicles overtaken	No. of vehicles in opposite direction
1	N-S	6-32	1-40	4	7	268
2	S-N	7-14	1-50	5	3	186
3	N-S	6-50	1-30	5	3	280
4	S-N	7-40	2-00	2	1	200
5	N-S	6-10	1-10	3	5	250
6	S-N	8-00	2-22	2	2	170
7	N-S	6-28	1-40	2	5	290
8	S-N	7-30	1-40	3	2	160

15. Estimate the theoretical capacity of a traffic lane with one way traffic flow at a stream speed of 40kmph. Assume the average space gap between vehicles to follow the relation $S_g = 0.278\ Vt$ where V is the stream speed in kmph, t is the average reaction time=0.7 sec; assume average length of vehicles =5.0 m

16. Two vehicles A and B approaching at right angles, A from West and B from south, collide with each other. After the collision, vehicle A skids in a direction 50° North of west

and vehicle B, 60o East of north. The initial skid distances of the vehicles A and B are 38 and 20 m respectively before collision. The skid distances after collision are 15 and 36 m respectively. If the weights of vehicles B and A are 6.0 and 4.4 tonnes, calculate the original speeds of the vehicles. The average skid resistance of the pavement is found to be 0.55

17. An isolated signal with pedestrian's indication is to be installed on right angled intersection with road A 18 m wide and road B, 12m wide. The heaviest volume per hour for each lane of road A and road B are 275 and 225, respectively. The approach speeds are 55 and 40 kmph, for A and B respectively. Design the timings of traffic and pedestrian signals.

18. The average normal flow of traffic on cross roads A and B during period are 400 and 250pcu per hour; the saturations flow values on these roads are estimated. as 1250 and 1000 pcu per hour respectively. The all- red time required for pedestrian crossing is 12 secs. Design two phase traffic signal by Webster's method.

19. Ata right angled intersection of two roads, Road 1 has four lanes with a total width of 12.0 m and Road 2 has two lanes with a total width of 6.6 m. The volume of traffic approaching the intersection during design hour are 900 and 743 PCU/ hour on the two approaches of Road 1 and 278 and 180 PCU/hour on the two approaches of Road 2. Design the signal timings as per IRC guidelines.

20. The following information was obtained from a transportation survey of a town:

Traffic zone number	Population in the zone (thousands)	Total trips generated (in hundreds)
1	26	12
2	28	11
3	31	17
4	33	15
5	32	12
6	30	15
7	20	9
8	25	13

CHOOSE THE CORRECT ANSWER

1. In a carriage way marking, the lane lines on straight road are of.......cm thick and ....m long
   A. 12,6
   B. 10,5

C. 8,4
D. None

2. Time allotted for green signal may be nearly ………seconds
   A. 5
   B. 10
   C. 15
   D. 20

3. No parking sign is in………..shape
   A. Circular
   B. Triangular
   C. Hexagonal
   D. Octagonal

4. The distance between each lane line in carriage way marking is……m
   A. 2
   B. 4
   C. 6
   D. 8

5. The area of most acute vision of a driver is a cone of………..
   A. 3^0
   B. 10^0
   C. 15^0
   D. 20^0

6. 'Fixed delay' in a highway is due to………..
   A. Pedestrians crossing the rod
   B. Parked vehicles
   C. Traffic signals
   D. Road repair

7. The purpose of a 'divisional island' is to eliminated…………
   A. Nose to tail collision
   B. Head on collision
   C. Side swipe
   D. Tail to tail collision

8. A channelization island provides………….
   A. Equal entry and exit widths
   B. Funnel shaped entry and wider exit
   C. Wider entrance and funnel shaped exit
   D. High relative speed at entry and slow speed at exit

9. The advantage of a rotary is………..
   A. Traffic is continuous motion

B. No waiting by traffic
C. Vehicles move in same direction
D. Left turn is relatively easy

10. Ungraded level crossing comes under………
    A. Warning sign
    B. Informatory sign
    C. Regulatory sign
    D. Route marker sign

11. The special signs intended to control, warn, regulate or guide the traffic is called……….(**Traffic marking**)

12. AADT stands for……(**Annual average daily traffic**)

13. The surveys carried out to analyse the traffic characteristics and collect traffic data is called…..(**Traffic sensus**)

14. The speed limit and vehicle control signs is which colour**………………….(white colour with red border)**

15. Relation between speed, travel, time, volume is…….($\mathbf{T_{(sec/km)}=\frac{3600}{V}}$)

Unit-IV: (INTERSECTION DESIGN)

Important points / Definitions:

1. **Intersection:** Intersection is includes not only the pavement area, but typically the adjacent sidewalks and pedestrian curb cut ramps. The intersection is defined as encompassing all alterations (for example, turning lanes) to the otherwise typical cross-sections of the intersecting streets.
2. **Traffic island:** Traffic Island is a solid or painted object in a road that channels traffic. It can also be a narrow strip of island between roads that intersect at an acute angle. ... Traffic islands can be used to reduce the speed of cars driving through, or to provide a central refuge to pedestrians crossing the road.
3. **Intersection at Grade:** All road intersections which meet at the same level allowing traffic movement like merging, diverging, crossing and weaving are called intersection at Grade.
4. **Grade separated Intersection:** Grade separation structures that permit the cross flow traffic at different levels without interruptions.
5. **Rotary intersection:** The rotary intersection of roads is also called as traffic **rotary** which is nothing but enlarged intersection of roads where vehicles cross roads or change their direction without stopping. All vehicles coming from different

roads move in single direction around the central island and diverges into required exit.

6. **Conflicts at Intersections:** Intersection are planned points of conflict in any roadway system. This includes U.S. and state highways, county roads and local streets. People – some in motor vehicles, others walking or biking – cross paths as they travel through or turn from one route to another.

7. **Cloverleaf interchange:** The intersection provided at the junction of all the major roads where space availability is more is called cloverleaf interchange.

8. **Diamond interchange:** When two highways cross each other and intersect minor road enabling a junction known as diamond interchange.

9. **Trumpet interchange:** when one major road terminated at another major road, then the interchanges is called as trumpet interchange.

10. **Partial cloverleaf interchange:** The Partial cloverleaf interchange is a modification which combines elements of a diamond interchange with one or more loops of a cloverleaf to eliminated critical turning conflicts.

SHORT ANSWER QUESTIONS

1. What do you understand by the term "At Grade intersection"

2. What is Channelization and why do we require it?

3. What is weaving length in the design of rotary intersection?

4. What are the Limitations of Rotary Intersection?

5. Mention various advantages of rotary intersection?

6. Explain the concept of traffic island in the design of intersections?

7. Explain the design requirements of at-grade intersections?

8. Explain about the various design factors of rotary in rotary intersection?

9. What do you understand by the term "Grade separated intersection?

10. Mention the advantages of channelized intersections?

LONG ANSWER QUESTIONS

1. List the advantages and disadvantages of rotary intersection?

2. What are the requirements of at grade Intersection and explain them?

3. What are the various types of at grade Intersections and explain them with neat sketches?

4. Explain in detail about on street parking?

5. What is Channelization and explain the importance with its advantages and disadvantages?

6. What are various types of Grade separated Intersections and explain them with neat sketches?

7. Briefly explain the various design factors to be considered in the design of rotary?

CHOOSE THE CORRECT ANSWER

1. The minimum width of carriage way at the entry and exit of rotary is…..m
   A. 4
   B. 5
   C. 9
   D. 10

2. Which of the following is not a shape of rotary Island…………
   A. Rectangular
   B. Circular
   C. Elliptical
   D. Turbine

3. Radius of rotary, R=………….
   A. $\frac{V}{125f}$
   B. $\frac{V.F}{127}$
   C. $\frac{V2}{127f}$
   D. $\frac{VX127}{f}$

4. The design speed of the vehicle in a traffic rotary adopted for urban areas is….kmph
   A. 20
   B. 30
   C. 40
   D. 50

5. The junction provided when the major road intersect a minor road is known as……..interchange
   A. Diamond
   B. Trumpet
   C. Cloverleaf
   D. Y

6. If an extra width is provided at an intersection area, then it is known as………..**(Flared intersection)**

7. The junction at which the intersection leg and the highway meets at right angle is known as………**(Trumpet interchange)**

8. The proportion of weaving-traffic is in the range of …….**(0.4 to 1.0)**

9. The design speed of the vehicles in a traffic rotary adopted for rural areas as………..**40 kmph**
10. The best angle of parking a vehicle is……..45^0

Unit-V: (Pavement Design)

Important points / Definitions:

1. **Flexible pavement:** The pavements which have very less flexural strength are called flexible pavement.
2. **Rigid pavement:** The pavements which possess worth flexural strength are called as rigid pavement.
3. **Sub-grade:** The finished and compacted surface of earthwork on which a road pavement rests is called sub-grade or formation.
4. **Sub-base:** A layer of granular material provided in between the sub-grade and the base course in a road pavement is known as sub-base.
5. **Base course:** A layer of boulders or bricks provided over the sub-base or immediately over the sub-grade in the absence of sub-base in a road pavement is called base course or soling or foundation course.
6. **Surface course:** The topmost layer of the road pavement directly exposed to traffic is called wearing or surface course.
7. **Temperature stresses:** Temperature stresses are developed in cement concrete pavement due to variation in slab temperature**.**
8. **Warping stresses:** Warping stresses due to daily variation resulting in a temperature gradient across the thickness of the slab.
9. **Frictional stresses:** Frictional stresses due to seasonal variation resulting in overall change in the slab temperature.
10. **Joints in rigid pavement:** Joints are the discontinuities in the concrete pavement slab helps to release the stresses due to temperature variation, sub-grade moisture variation, shrinkage of concrete etc…….

SHORT ANSWER QUESTIONS [2M]

1. Explain the flexible pavement?
2. Explain the Rigid pavement?
3. Explain the flexible pavement failures?
4. Explain the Rigid pavement failures?
5. Explain the stresses acting on rigid pavement?
6. What is temperature stress?
7. What is Warping stresses?
8. Write the frictional stresses?
9. Write a short note on Contraction joint?
10. Write a short note on Longitudinal joint? (may-2018)

LONG ANSWER QUESTIONS[5M]

1. Explain the different types of stresses on rigid pavement?
2. Explain design recommendation for flexible pavement by CBR method as per IRC 37-2012
3. Explain theory of empirical mechanistic method and also state its advantages?
4. What are the different mechanistic model? Explain any one in short.
5. Why joints are necessary in concrete pavements. State various types of joints. Explain any one in brief? (May-2018,May-2016. Dec-2017)
6. Explain design of overlay by Benkelman beam method?
7. What are the equipment used in Benkelman beam method? Explain the procedure of Benkelman beam method.
8. Explain the different types of joints?
9. Calculate the stress at interior, edge and corner of a cement concrete pavement using Westergaard stress equations, use the following data
   Design Wheel load=5100 kg
   Pavement thickness h=20 cm
   Modulus of elasticity of concrete=3×10^5 kg/cm^2
   Poisson ratio of concrete is 0.15
   Modulus of sub-grade reaction K=6 kg/cm^3
   Radius of concrete area a=15 cm

10. Determine the warping stresses at interior, edge and corner regions in a 25cm thick concrete pavement with transverse joints at 11 m interval and longitudinal joints at 3.6m intervals. The modulus of subgrade reaction K is 6.9 kg/cm^3. Assume temperature differential for day conditions to be 0.6 ^{0}C per cm slab thickness. Assume radius of loaded area as 15 cm for computing warping stress at the corner. Additional data are given below
    e=10×10^{-6} per ^{0}C
    E=3×10^5 kg/cm^2
    μ=0.15

CHOOSE THE CORRECT ANSWER

1. Total thickness of pavement………….
   A. Constant
   B. Charges with sub-grade
   C. Changes with sub-base
   D. Changes with base

2. The design factor not considered in CBR is………..
   A. Weather
   B. Traffic
   C. VDF
   D. Grow rate

3. The overlay design is laid for a maximum life span of……..
   A. 5 year
   B. 7 year
   C. 9 year
   D. 10 year

4. The most commonly used overlay is………..
   A. Flexible over rigid
   B. Rigid over Flexible
   C. Flexible over Flexible
   D. Rigid over rigid
5. The VDF of a lane if the (CVPD) is greater than 1500 in plain terrain………
   A. 4.5
   B. 2.5
   C. 3.0
   D. 4.0
6. The Tie bars in cement concrete pavements are at……….
   A. Longitudinal joint
   B. Expansion joint
   C. Contraction joint
   D. Warping joint
7. Rigid pavements are designed by…………..
   A. Rigid plate theory
   B. Elastic plate theory
   C. Infinite layer theory
   D. Interlocking of aggregates
8. Factor that least affect the pavement is………..
   A. Speed of vehicle
   B. Wheel load
   C. Axle configuration
   D. Load repetition
9. The maximum wheel load stress is developed in the rigid pavement at……..
   A. Edge portion
   B. Corner portion
   C. centre
   D. All
10. Standard axle load is………..
    A. 40 KN
    B. 60 KN
    C. 80.2 KN
    D. 8.2KN
11. The lane distribution factor for two lane road with single carriage way is……….(**0.75)**
12. The layer note required in cement road is ………(**Base)**
13. The stress in pavement charges………(**Daily)**
14. Warping stress coefficient charts were prepared by……….(**Bradbary)**
15. The deflection in Westergaard analysis is………….(**0.125)**