TRANSPORTATION ENGINEERING

CLASSIFICATION OF ROADS.

(1) Based on weather.

(i) All-weather roads

(ii) Fair-weather roads

(2) Based on the type of carriage way or road pavement.

(i) Paved roads

(ii) Unpaved roads (*e.g.* earth roads and gravel roads)

(3) Based on the type of pavement surfacing provided.

(i) Surfaced roads

(ii) Unsurfaced roads

(4) Based on method of construction.

***(i)* Traffice volume (vehicle) :**

(a) Heavy traffic road;

(b) Medium traffic road,

(c) Light traffic roads

***(ii)* Load transported or tonnage :**

(a) Class I or Class A (tonnes/day),

(b) Class II or Class B etc.

***(iii)* Location and function.**

MODIFIED CLASSIFICATION OF ROAD SYSTEM.

(Given by Third Road Development Plan 1981-2001.)

1. Primary system.

(i) Expressway

(ii) National Highway (NH)

2. Secondary system.

(i) State Highway (SH)

(ii) Major District Roads (MDR)

3. Tertiary system or Rural roads.

(i) Other District Road (ODR)

(ii) Village Road (VR)

CLASSIFICATION OF URBAN ROADS OTHER THAN EXPRESSWAYS.

(1) Arterial roads

(2) Sub-arterial roads

(3) Collector streets

(4) Local streets

ROAD PATTERNS.

(1) **Rectangular or block pattern :** Adopted in the city roads of Chandigarh

(2) Radial or star and block pattern.

(3) Radial or star and circular pattern : *e.g.* Connaught place

(4) Radial or star and grid pattern : Nagpur road plan formulae were prepared assuming star and grid pattern

(5) Hexagonal pattern

(6) Minimum travel pattern

PLANNING SURVEYS.

It consists of : Economic studies, Financial studies, Traffic or road use studies, Engineering studies

Highway planning phase.

It includes :

(i) Assessment of road length requirement for an area. (It may be a district, state or the whole country)

(ii) Preparation of master plan showing the phasing of plan in annual or five year plans.

Thus, for assessing the road length requirement, field surveys are carried out to collect the data required for determining the length of the road system. The field survey thus required for collecting the *factual data* may be called *planning surveys* or *fact finding surveys.*

HIGHWAY PLANNING IN INDIA

Nagpur road plan or First 20 year road plan (1943-1963).

Road network in the country was classified into five categories :

(i) National Highways *(ii)* State Highways

(iii) Major District Roads *(iv)* Other District Roads

(v) Village Roads.

HIGHWAY ALIGNMENT.

The position of the layout of the centre line of the highway on the ground is called the *alignment.*

Basic requirements of an ideal alignment between two terminal stations.

It should be : short, easy, safe and economical

Factors controling highway alignment.

(i) Obligatory points *(ii)* Traffic

(iii) Geometric design *(iv)* Economics

(v) Other considerations

SURVEYS

Engineering Surveys for Highway Location.

Before a highway alignment is finalised in highway project, the engineering surveys are to be carried out.

Survey stages.

The *survey may be completed in four stages.*

(1) Map study

(2) Reconnaissance

(3) Preliminary survey.

(*a*) Conventional approach by preliminary survey.

Procedure : It is carried out in following steps :

(i) Primary traverse

(ii) Topographical features

(iii) Levelling work

(iv) Drainage studies and Hydrological data

(v) Soil survey

(vi) Material survey

(vii) Traffic survey

(viii) Determination of final centre line.

(b) Modern rapid approach by aerial survey.

(4) Final location and Detailed survey.

The alignment finalised at the design office after the preliminary survey is to be first located on the field by establishing the centre line. Next detailed survey should be carried out for collecting the information necessary for the preparation of plans and construction details for the highway project.

The data collected during the detailed survey should be elaborate and complete for preparing detailed plans, design and estimates of the project.

HIGHWAY CROSS-SECTION ELEMENTS.

(1) Pavement surface characteristics.

Friction : This lies between vehicle tyres and pavement surface in **longitudnal direction.**

Skid : It occurs when the wheels slide without revolving (similar to friction)

SKID

Longitudinal	Lateral
When path travelled along the road surface is greater than the circumferential movement of the wheels due to rotation	When centrifugal force is the contr-acting force.

Slip.

Slipoccurs when a wheel revolves more than the corresponding longitudinal movement along the roads.

Factors affecting friction or skid resistance.

(i) Type of pavement surface : e.g. c.c., WBM, earth, etc.

(ii) Condition of pavement : e.g. wet, dry, smooth or rough etc.

(iii) Type and condition of tyre : e.g. new or old

(iv) Speed of the vehicle

(v) Extent of brake application

(vi) Load and tyre pressure

(vii) Temperature of tyre and pavement

(viii) Type of skid : e.g. long, late etc.

(2) Camber or Cross-slope.

It is the slope provided to the road surface in transverse direction to drain off the rain water from the road surface. It is Expressed as $x\%$ or x in 100.

Shape of the camber :

(i) Parabolic

(ii) Elliptic : preferred by fast moving vehicles and two lane highway; or

(iii) Straight line : Preferred in the cross-section if cross-slope is flat as in cement concrete pavements.

Nonte : Camber depends on different types of road surfaces, but generally camber is half of the longitudinal gradient of road.

(3) Width of pavement or carriageway.

The pavement or carriageway width depends on the width of traffic lane and number of lanes.

Width of 3.75 m is considered desirable for a road having single lane for vehicles of maximum width 2.44 m.

For pavement having two or more lanes, width of 3.5 m per lane is considered sufficient.

Maximum width of vehicles as per IRC specifications is 2.44 m.

(4) Kerb.

It is the boundary between pavement and the shoulder.

(5) Road margins.

The various elements included in the road margins are :

shoulder, parking lane, frontage road, driveway, cycle track, footpath, guard rail and embankment slope.

Shoulders : These are provided along the road edge to serve as an emergency lane. The minimum shoulder width recommended by the IRC is 2.5 m.

(6) Width of Roadway or Formation.

Width of formation of roadway is the sum of widths of pavements or (carriageway including separator, if any) and the shoulders.

(7) Right of way.

It is the area of land acquired for the road, along its alignment. The width of this acquired land is known as **land width** and it depends on the importance of the road and possible future development.

The normal land width required for the N.H. and S.H. on open plain terrain is 45 m and the maximum land width required is 60 m, the corresponding width between the building lines is 80 m and that between the control lines is 150 m, thus allowing set back distances of 10 and 45 m beyond the road boundary line with the maximum recommended road width.

SIGHT DISTANCE.

It is the length of road visible ahead to the driver at any instance.

Three sight distance situations are considered in the design :

(1) Stopping Sight Distance (SSD).

The minimum sight distance available on a highway at any instant or spot should be of sufficient length to stop a vehicle travelling at design speed, safely without collision with any other obstruction.

(2) Overtaking Sight Distances (OSD).

The minimum distance open to the vision of the driver of a vehicle intending to overtake slow vehicle ahead with safety against the traffic of opposite direction is called minimum *overtaking sight distance* (OSD) or *safe passing sight distance*.

(3) Sight Distance at Intersections.

The IRC recommends that at uncontrolled intersections, sufficient visibility should be provided such that the sight distance on each road is atleast equal to the SSD corresponding to the design speed of the road.

IRC recommends that a minimum visibility distance of 15 m along the minor road and a distance of 220, 180, 145 and 110 m along the major road corresponding to design speeds of 100, 80, 65 and 60 kmph. respectively may be provided.

SUPERELEVATION.

In order to counteract the effect of centrifugal force and to reduce the tendency of vehicle to overturn or skid, outer edge of the pavement is raised with respect to the inner edge, thus providing a transverse slope throughout the length of horizontal curve. This transverse inclination to the pavement surface is called *superelevation* or *cant* or *banking*.

HORIZONTAL TRANSITION CURVE.

Functions of the transition curves in the horizontal alignment of highway :

(*i*) To introduce gradually the centrifugal force between tangent point and the beginning of the circular curve, avoiding a sudden jerk on the vehicle.

(*ii*) To enable the driver turn the steering gradually for his own comfort and security.

(*iii*) To enable gradual introduction of the designed superelevation and extra widening of pavement at the start of the circular curve.

(*iv*) To improve aesthetical appearance of the road.

HIGHWAY MATERIAL

SUB-GRADE SOIL

It is an integral part of the road pavement structure. The main function of the sub-grade is to give adequate support to the pavement and for this, the subgrade should possess sufficient stability under adverse climate and loading conditions.

STONE AGGREGATES.

Aggregates form the major portion of pavement structure and they form the prime materials used in pavement construction.

Desirable properties of road aggregates.

(1) Capable of withstanding high stresses in addition to wear and tear.

(2) Aggregate should be hard enough to resist the wear due to abrasive action of traffic.

(3) Aggregate should be able to resist impact produced by heavily loaded steel tyred vehicles.

(4) The stone used in the pavement construction should be durable and should resist disintegration due to action of weather.

(5) Too flaky and too much elongated aggregate should be avoided as far as possible in road construction.

(6) The aggregates used in bituminous pavements should have less affinity with water when compared with bituminous materials.

TEST FOR ROAD AGGREGATES.

(1) Crushing test : The aggregate crushing value provides a relative measure of resistance to crushing under gradually applied compressive load.

(2) Abrasion test : Abrasion tests are carried out to test the hardness property of stones and to decide whether they are suitable for the different road construction works.

(3) **Impact test :** A test designed to evaluate the toughness of stone or resistance of the aggregates to fracture under repeated impacts is called **impact test**. The aggregate impact value indicates a relative measure of resistance of aggregate to impact, which has a different effect than the resistance to gradually increasing compressive stress.

(4) **Soundness test :** Soundness test is conducted to study the resistance of aggregates to weathering action.

(5) **Shape test :**

Flakine index : It is the percentage by weight of aggregate particles whose least dimesion/ thickness is less than 0.6 of their mean dimension. This test is applicable for sizes larger than 6.3 mm

Elongation index : It is the percentage by weight of particles whose greatest dimension or length is greater than 1.8 times their dimensions. This test is not applicable for size smaller than 6.33mm.

(6) **Specific gravity and Water absorption test :** The specific gravity of rocks vary from 2.6 to 2.9. Rock specimens having more than 0.66% water absorption are considered unstisfactory unless found acceptable based on strength tests.

(7) **Bitumen adhesion test :** Adhesion problem of bitumen with aggregate are observed due to the pressure of water. Water liking aggregates are called *hydrophiopic aggregate* and they have greater altration of bitumen than water.

BITUMINOUS MATERIALS.

When the bitumen contains some inert material or minerals, it is sometimes called **asphalt**.

Bitumen available in India is classified into two categories :

(1) *A type* : as grades A35, A90, etc.

(2) *S-type* : as grades S35, S90, etc.

Types of bituminous materials.

(*i*) **Bitumen :** It is Obtained by the distillation of petroleum crude.

(*a*) Petrolium bitumen : The successive fractions obtained yield gasoline, naphtha, kerosene and lubricating oil; the residue would be petroleum bitumen.

(b) Native asphalt

(*ii*) **Tar :** It is obtained by the destructive distillation of coal or wood in the absence of air.

Comparison of Tar and Bitumen :

	Bitumen		***Tar***
1.	Bitumen have black to dark brown colour	1.	Tar have black to dark brown colour.
2.	Bitumen is a petroleum product	2.	Tar is produced by destructive distilis-ation of coal or wood.
3.	Bitumen is soluble in carbon disulphite and in CCl_4	3.	Tar is soluble only in toluene
4.	More weather resistence property	4.	Less weather resistance property
5.	Bitumen is less temperature susceptible	5.	Tar is more temperature susceptible

Characteristics of bitumen.

(*i*) It is a measure of its resistance to crushing and to abrasion at the surface.

(*ii*) It is a property that enables to resist at any fracture when subjected to impact due to moving vehicles.

TESTS ON BITUMEN.

(1) **Penetration test**

(2) **Ductility test :** The ductility is expressed as the distance in centimeters to which a standard briquette of bitumen can be stretched before the thread breaks.

(3) **Viscosity test :** Viscosity is measured by Orifice type viscometer.

(4) **Float test**

(5) **Specific gravity test :** Specific gravity of bituminous materials is defined as the ratio of mass of a given volume of the substance to the same of an equal volume of water when temperature of both being 27°C.

(6) **Softening point test :** Softening point is the temperature at which the substance attains a particular degree of softening under specified condition of test.

(7) **Flash and Fire point test**

Flash point : Flash point of a material is the lowest temperature at which the vapour of a substance momentarily takes fire in the form of a flash under specified condition of test. The minimum specified flash point of bitumen is 175°C.

Fire point : Fire point is the lowest temperature at which the material gets ignited and burns under specified conditions of test.

Pensky Martens closed cup apparatus or open cup are used for conducting the test.

(8) **Solubility test :** Pure bituman is completely soluble in solvents like carbon disulphide and carbon tetrachloride.

(9) **Spot test**

(10) **Loss on heating test**

(11) **Water content test**

CUTBACK BITUMEN

It is defined as the bitumen, the viscosity of which has been reduced by a volatile diluent.

The cutback with the lowest viscosity is designated by numeral 0. Suffix numerals 0, 1, 2, 3, 4 and 5 designate progressively thicken more viscous cutback as the number increases.

Types of cutback Bitumens.

(*i*) Rapid Curing (RC)

(*ii*) Medium Curing (MC)

(*iii*) Slow Curing (SC)

Bituminous Emulsion.

Bitumen emulsion is a liquid product in which a substantial amount of bitumen is suspended in a finely divided condition in an aqueous medium and stabilized by means of one or more suitable materials.

Grades of Tar.

There are five grades of road tars based on their viscosity and other properties

RT-1 : Lowest viscosity and is used for surface pointing.

RT-2 : Recommended for standard surface painting under normal Indian climatic conditions

RT-3 : Used for premixing chips for top coarse and light carpets

RT-4 : Used for premixing tar macadam in base course, and

RT-5 : Used for grouting purpose.

Based on their viscosity RT-1 has the lowest viscosity and is used for surface painting under exceptionally cold weather as this has very low viscosity.

Bituminous paving mixes.

Bituminous concrete or asphaltic concrete is one of the highest and costliest types of flexbile pavement layer used in the surfacing course.

Desirable properties of a good bituminous mix :

(*i*) Stability

(*ii*) Durability

(*iii*) Flexibility

(*iv*) Skid resistance

(*v*) Workability.

HIGHWAY PAVEMENTS

It is always desirable to construct the pavement in which subgrade is always dry even during monsoons.

Types of Pavement Structures.

(1) **Flexible pavements :** A typical pavement consists of four layers.

(*i*) Soil subgrade

(*ii*) Sub-base course

(*iii*) Base course

(*iv*) Surface course

The flexible pavement may be constructed in a number of layers and the top layer has to be the strongest as the highest compressive stresses are to be sustained by this layer in addition to the wear and tear due to the traffic.

Flexible pavements are commonly designed using empirical design charts or equations taking into account some of the design factors. There are also semi-empirical and theoretical design method.

(2) **Rigid pavements :** A typical rigid pavement consists of three layers.

(*i*) Soil subgrade

(*ii*) Base course

(*iii*) Cement concrete slab as wearing surface.

(3) **Semi-rigid pavements.**

When bonded materials like the pozzolanic concrete, lean cement concrete or soil cement are used in the base course or sub-base course layer of the pavements then they are called semi-rigid pavements.

STRENGTH CHARACTERISTICS OF PAVEMENTS.

Elastic modulii values of the following are determined by plate bearing tests :

(*i*) Subgrade modulus (E_S)

(*ii*) Elastic modulii of base course and sub-base course materials.

EXERCISE - I

1. Minimum width of the pavement on a National highway should be

(*a*) 4.7m (*b*) 5.7m

(*c*) 6.7m (*d*) 7.7m

2. Character of traffic means

(*a*) average speed of vehicles

(*b*) speed of vehicles

(*c*) whether the traffic is motor traffic or steel tyre traffic or both

(*d*) none of the above

3. When the path travelled by a vehicle along the road surface is more than the circumferential movement of the tyres, then it is known as

(*a*) braking (*b*) slipping

(*c*) skidding (*d*) acceleration

4. Which of the following is not matched correctly ?

Road	(Ruling design speed kmph)	
(*a*) National highway	plain terrain	100
(*b*) Major district road	rolling terrain	65
(*c*) Other district road	plain terrain	65
(*d*) Village road	plain terrain	40

5. Which of the following is not matched correctly

Road	(Minimum ruling radius of horizontal curves)
(*a*) National highway	360m
(*b*) State highways	270m
(*c*) Major district roads	230m
(*d*) Other district roads	155m

6. Maximum ruling gradient in mountaneous area is

(*a*) 1 in 30 (*b*) 1 in 20

(*c*) 1 in 16.7 (*d*) 1 in 12

7. For water bound macadams, the camber should be

(*a*) 1–2% (*b*) 2–2.5%

(*c*) 2.5–3% (*d*) 3–4%

8. For the horizontal curve design, the lateral coefficient of friction recommended by IRC is

(*a*) 0.15 (*b*) 0.25

(*c*) 0.35 (*d*) 0.4

9. Maximum allowable super elevation in plain and rolling terrain is

(*a*) 6.7% (*b*) 10%

(*c*) 7.0% (*d*) none of these

10. Minimum superelevation on curves should not be less than

(*a*) 5% (*b*) 4%

(*c*) camber (*d*) none of these

11. Minimum value of super elevation for concrete pavements is

(*a*) 1 in 72 (*b*) 1 in 60

(*c*) 1 in 50 (*d*) 1 in 90

12. Test carried out to determine hardness property of road aggregates is

(*a*) Aggregate crushing test

(*b*) Los Angles abrasion test

(*c*) Aggregate impact test

(*d*) Soundness test

13. A bitumen of grade 80/100 means

(*a*) the penetration value of bitumen ranges from 80 to 100

(*b*) the fire and flash points are 80□C and 100□C

(*c*) the fire and flash points are 100□C and 80□C

(*d*) the fluidity ranges between 80□C and 100□C

14. Tie bars in cement concrete pavements are provided at

(*a*) Contraction joints (*b*) Expansion joints

(*c*) Longitudinal joints (*d*) Warping joints

15. Magnitude of tyre pressure, controls the

(*a*) total thickness of pavement

(*b*) number of layers to be provided in the pavement

(*c*) type of subbase and base course

(*d*) quality of materials to be used in the upper layers of the pavement

16. Bottom most layer of a pavement is called

(*a*) subgrade (*b*) base course

(*c*) sub-base course (*d*) wearing course

17. Most suitable material for highway embankment is

(*a*) silt

(*b*) granular soil

(*c*) organic soil

(*d*) clays

18. Main drawback of CBR method is that
(*a*) it does not take fully into account the damaging effects of heavier wheel loads and their frequency
(*b*) it does not consider whether the road is for multi lane single carriageway or dual carriage way
(*c*) design curve only gives the value for the total thickness of pavement for different traffic intensity and CBR value of subgrade
(*d*) all of these

19. Tie bars in cement concrete pavements are provided at
(*a*) longitudinal joints (*b*) expansion joints
(*c*) contraction joints (*d*) both (*b*) and (*c*)

20. Commonly used roller for compacting clayey soil is
(*a*) sheep foot roller (*b*) smooth wheeled roller
(*c*) pneumatic roller (*d*) none of these

21. In hill roads, the side drains are provided
(*a*) only on the hill side of road
(*b*) only on the opposite side of road
(*c*) both (*a*) and (*b*)
(*d*) none of these

22. Most common method for stabilization of sandy soil is
(*a*) soil lime stabilization
(*b*) soil cement stabilization
(*c*) soil bitumen stabilization
(*d*) mechanical stabilization

23. Test conducted on Los Angles testing machine is
(*a*) attrition test
(*b*) barasion test
(*c*) impact test
(*d*) crushing strength test

24. The toughness of road aggregates is mesured by
(*a*) attrition test
(*b*) abrasion test
(*c*) impact test
(*d*) crushing strength test

25. Binder for flexible pavement construction is
(*a*) bitumen (*b*) clay
(*c*) lime (*d*) cement

26. Bitument of grade 80/100 means its penetration value is
(*a*) 8m (*b*) 10mm
(*c*) 8 to 10mm (*d*) none of these

27. The bitument of grade 80/100 indicates
(*a*) dynamic viscosity (*b*) kinematic viscosity
(*c*) specific gravity (*d*) penetration

28. The temperature susceptibility of bitumen is determined by
(*a*) softening point test (*b*) flash point test
(*c*) penetration test (*d*) solubility test

29. CBR pavement design curves gives
(*a*) thickness of the layer
(*b*) thickness of the curve to be provided over this layer
(*c*) equivalent single wheel load
(*d*) none of these

30. In CBR test, the value of CBR is calculated at
(*a*) 2.5mm penetration (*b*) 5.0 mm penetration
(*c*) both (*a*) and (*b*) (*d*) none of these

31. Road tar is not preferred in road construction because it is
(*a*) temperature sensitive
(*b*) not water resistant
(*c*) useful for other industry
(*d*) all of these

32. A bituminous substance is tested for
(*a*) consistency (*b*) specific gravity
(*c*) softening point (*d*) all of these

33. Specific gravity of bitumen is determined by
(*a*) hydrometer (*b*) pycnometer
(*c*) viscometer (*d*) all of these

34. Bitumen is soluble in
(*a*) diesel (*b*) water
(*c*) petrol (*d*) carbon disulphide

35. The pavement suitable for very heavy traffic load is
(*a*) cement concrete
(*b*) R.C.C.
(*c*) surface dressed macadam
(*d*) bituminous grouted macadam

36. Life of a cement concrete road is taken as
(*a*) one year (*b*) five years
(*c*) 10–15 years (*d*) 25–30 years

37. An ideal pavement is constructed of
(*a*) cement concrete
(*b*) bricks
(*c*) stones
(*d*) bitumen

38. A road suitable for very heavy traffic load is
(*a*) surface dressed macadam
(*b*) cement concrete
(*c*) reinforced cement concrete
(*d*) all of these

39. A cement grouted road is an example of
(*a*) semi-rigid pavement
(*b*) rigid pavement
(*c*) flexible pavement
(*d*) none of these

40. Weight of a vehicle affects
(*a*) passing sight distance
(*b*) extra widening
(*c*) pavement thickness
(*d*) width of lanes

41. The California Bearing Ratio method of flexible pavement design gives an idea about
(*a*) quality of road making material
(*b*) traffic intensities
(*c*) characteristics of soil
(*d*) all of these

42. Main disadvantage of concrete roads is that
(*a*) initial cost is high
(*b*) it requires skilled personnel for construction
(*c*) it requires cautious handling of the materials
(*d*) all of these

43. Major function of reinforcement, in concrete pavements, is to
(*a*) strengthen the slab
(*b*) hold together the cracks
(*c*) control the development of cracks
(*d*) both (*b*) and (*c*)

44. A large difference of temperature between top and bottom of the slab causes
(*a*) hardening (*b*) warping
(*c*) crazing (*d*) all of these

45. Gradients at hair pin bends or other sharp corners within side curves of 10 to 15m should not exceed
(*a*) 1 in 10 (*b*) 1 in 20
(*c*) 1 in 40 (*d*) 1 in 50

46. Function of the pavement is to
(*a*) provide smooth riding surface
(*b*) distribute the wheel loads over soil
(*c*) protect the soil formation from adverse effects of weather
(*d*) all of these

47. Tar
(*a*) is a petroleum product
(*b*) does not coat the aggregate so easily as bitumen does
(*c*) has inferior weather resisting property in comparison to bitumen
(*d*) has free carbon content less than that in the bitumen

EXERCISE - II
(Questions From Previous SSC CPWD Exams)

2011

1. The camber for hill roads in case of bituminous surfacing is adopted as
(*a*) 2.0%
(*b*) 2.5%
(*c*) 3.0%
(*d*) 3.5%

2. The standard consistency test is done in a
(*a*) Blaine's apparatus
(*b*) Le-Chatelier's apparatus
(*c*) Vane apparatus
(*d*) Vicat's apparatus

2012

3. When the bituminous surfacing is done on already existing black top road or over existing cement concrete road, the type of treatment to be given is
(*a*) Tack coat
(*b*) Spray of emulsion
(*c*) Seal coat
(*d*) Prime coat

4. Bottommost layer of pavement is known as
(*a*) Sub base course (*b*) Sub grade
(*c*) Wearing course (*d*) Base course

5. The member of roof truss which supports the purlins is called as

(*a*) Sag rod (*b*) Main strut

(*c*) Principal rafter (*d*) Principal tie

2013

6. If the stopping distance and average length of a vehicle are 18 m and 6 m respectively, then the theoretical maximum capacity (vehicles per hour) or a traffic lane at a speed of 10 m/sec is

(*a*) 1500 (*b*) 2000

(*c*) 2500 (*d*) 3000

7. In highway construction on superelevated curves, the rolling shall proceed from

(*a*) sides towards the centre

(*b*) centre towards the sides

(*c*) low edge towards the upper edge

(*d*) upper edge towards the lower edge

2014

8. The following document contains detailed description of all items of work excluding their quantities, along with the current rates :

(*a*) Analysis of rates (*b*) Tender document

(*c*) Abstract estimate (*d*) Schedule of rates

9. The specific gravity of bitumen is

(*a*) 2.09 (*b*) 0.8

(*c*) 0.9 (*d*) 1.09

10. As per IS 456-2000. In the absence of test data, the approximate value of the total strain for design may be taken as :

(*a*) 0.004

(*b*) 0.001

(*c*) 0. 002

(*d*) 0.003

11. Most accurate method of estimation is base on

(*a*) Building cost index estimate

(*b*) Plinth area estimate

(*c*) Detailed estimate

(*d*) Cube rate estimate

12. For constructing road pavements, the type of cement generally used is

(*a*) ordinary Portland cement

(*b*) rapid hardening cement

(*c*) low heat cement

(*d*) blast furnace slag cement

ANSWERS

EXERCISE - I

1. (*b*)	**2.** (*c*)	**3.** (*c*)	**4.** (*d*)	**5.** (*b*)	**6.** (*b*)	**7.** (*c*)	**8.** (*a*)	**9.** (*a*)	**10.** (*c*)
11. (*a*)	**12.** (*b*)	**13.** (*a*)	**14.** (*c*)	**15.** (*d*)	**16.** (*a*)	**17.** (*b*)	**18.** (*d*)	**19.** (*a*)	**20.** (*a*)
21. (*a*)	**22.** (*c*)	**23.** (*b*)	**24.** (*c*)	**25.** (*a*)	**26.** (*c*)	**27.** (*d*)	**28.** (*a*)	**29.** (*b*)	**30.** (*c*)
31. (*a*)	**32.** (*d*)	**33.** (*b*)	**34.** (*d*)	**35.** (*c*)	**36.** (*d*)	**37.** (*a*)	**38.** (*c*)	**39.** (*a*)	**40.** (*c*)
41. (*a*)	**42.** (*d*)	**43.** (*d*)	**44.** (*b*)	**45.** (*b*)	**46.** (*d*)	**47.** (*c*)			

EXERCISE - II

1. (*b*)	**2.** (*d*)	**3.** (*a*)	**4.** (*b*)	**5.** (*c*)	**6.** (*a*)	**7.** (*c*)	**8.** (*d*)	**9.** (*d*)	**10.** (*d*)
11. (*c*)	**12.** (*b*)								

EXPLANATIONS

EXERCISE - II

1. Spacing of stirrup in a rectangular beam increased at the centre of the beam.

2. Slenderness $(\lambda) = \frac{l_{eff}}{r_{min}}$

Now, radius of gyration,

$$r = \sqrt{\frac{I}{a}}$$

$$= \sqrt{\frac{\frac{\pi}{64} \times D^4}{\frac{\pi}{4} \times D^2}}$$

$$= \sqrt{\frac{D^4}{16D^2}} = \frac{D}{4}$$

Hence slenderness,

$$\lambda = \frac{l}{r}$$

$$= \frac{400}{\frac{D}{4}}$$

$$= \frac{400 \times 4}{40}$$

$$= 40$$

6. Relationship between void ratio 'e' and porosity 'n'-

$$n = \frac{e}{1+e}$$

$$\therefore \quad n = e(1-n)$$

$$\therefore \quad 1-n = \frac{1}{1+e}$$

7. R.F. (Representative Fraction) which is always written with the map distance as 1 and is independent of any unit of measure.

Hence 1 cm on a map represents 10 m on the ground, the representative fraction of the scale is

$$RF = \frac{1}{1000}$$

8. **Schedule of Rate** is a list of rates of various items of works. This type of document contains detailed description of all items of work excluding their quantities, along with the current rates.

9. The specific gravity of bitumen is 1.09.

10. In the absence of test data, the approximate value of the total strain for design may be taken as 0.003.

As per IS 456-2000. In the absence of test data, the approximate value of the total shrinkage strain for design may be taken as 0.0003.

■■