



Zeal Education Society's
ZEAL POLYTECHNIC, PUNE.

NARHE | PUNE -41 | INDIA

SECOND YEAR (SY)

DIPLOMA IN CIVIL ENGINEERING

SCHEME: I

SEMESTER: III

NAME OF SUBJECT: Highway Engineering
Subject Code: 22302

MSBTE QUESTION PAPERS & MODEL ANSWERS

- 1. MSBTE WINTER-18 EXAMINATION**
- 2. MSBTE SUMMER-19 EXAMINATION**
- 3. MSBTE WINTER-19 EXAMINATION**

22302

11819

3 Hours / 70 Marks

Seat No.

--	--	--	--	--	--	--	--	--

- Instructions :**
- (1) All Questions are *compulsory*.
 - (2) Answer each next main Question on a new page.
 - (3) Illustrate your answers with neat sketches wherever necessary.
 - (4) Figures to the right indicate full marks.
 - (5) Assume suitable data, if necessary.
 - (6) Use of Non-programmable Electronic Pocket Calculator is permissible.
 - (7) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

Marks

1. Attempt any FIVE of the following :

10

- (a) State two characteristics of Road Transport.
- (b) Define Kerb and Right of way.
- (c) Define Camber and Super-Elevation.
- (d) Define Flakiness Index and Elongation Index.
- (e) List various types of curves provided on Hill Roads.
- (f) State the necessity of providing catch water drain in Hill Roads.
- (g) State two causes of Landslides.

- 2. Attempt any THREE of the following : 12**
- (a) Classify the Roads according to Nagpur Road Plan.
 - (b) Define Design Speed. Give four factors affecting Design Speed.
 - (c) Define gradient. Explain types of gradient. (Any Two)
 - (d) State and explain functions of Pavement Components.
- 3. Attempt any THREE of the following : 12**
- (a) Explain the construction procedure of Bituminous Road.
 - (b) Explain Softening Point Test on Bitumen with neat sketch.
 - (c) State different types of Tar used in construction of Road with its suitability.
 - (d) Define Passenger Car unit. Give factors affecting it.
- 4. Attempt any THREE of the following : 12**
- (a) List causes of Accident. Draw Collision diagram for Head-on-Collision.
 - (b) Explain preventive measures that can be taken to avoid Landslides in hilly area.
 - (c) Draw a typical cross-section of Hill Road and label all component parts.
 - (d) State the functions of surface drainage and sub-surface drainage.
 - (e) Draw a neat sketch (Plan & Section) of Longitudinal drain and Cross drain.
- 5. Attempt any TWO of the following : 12**
- (a) Calculate the Stopping Sight Distance for two way traffic in a Single Lane Road. The design speed of the Road is 60 kmph. Assume Reaction time of the driver as 2.5 sec and Co-efficient of friction as 0.6. Brake efficiency is 50%.
 - (b) Draw a neat cross-section of National Highway in Embankment.
 - (c) State the methods of construction of Cement Concrete Road. Explain any one method.

6. Attempt any TWO of the following :**12**

- (a) Draw Traffic Signs for
 - (i) Left Turn Prohibited
 - (ii) No Parking
 - (iii) Speed Limit – 60 kmph
 - (iv) Width Limit – 2m
 - (v) Narrow Bridge
 - (vi) Compulsory Ahead or Turn Right
 - (b) Explain Rotary Island (Traffic Island) with a neat sketch.
 - (c) Justify the remedial measures for following defects :
 - (i) Formation of Potholes in Case of WBM Roads.
 - (ii) Formation of Ruts in Case of Earthen Roads.
 - (iii) Bitumen Bleeding in Case of Bituminous Roads.
-



WINTER – 18 EXAMINATION

Subject Name: Highway Engineering

Model Answer

Subject Code:

22302

Important Instructions to examiners:

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q. N.	Answer	Marking Scheme
Q.1		<i>Attempt any FIVE of the following.</i>	(10)
Q.1	a) Ans:-	<i>State two characteristics of Road Transport.</i> Characteristics of road transport- 1) Road transport offers complete freedom to road user to transfer the vehicle from one lane to other. 2) It gives quick and easy transportation of men, machineries, materials etc. 3) Road transport serves the agricultural area by transporting of goods. 4) Roads are used by various categories of vehicles. 5) Construction and maintenance of road transport is cheaper 6) Road transport is a basic need in case of fire and police protections. 7) It gives door step connectivity even in case of rural area or villages. 8) It is important access to reach railways, waterways and airways.	01 M each (any two)
Q.1	b) Ans:-	<i>Define Kerb and Right of way.</i> Kerb: - The boundaries between the pavement and shoulders and footpaths are known as Kerb. Right of way: - The area of the land acquired for construction and development of a road along its alignment is known as right way.	01 M each
Q.1	c) Ans:-	<i>Define Camber and super-Elevation.</i> Camber: - The convexity provided to the surface of the carriage way is called as camber. Super-elevation: - The inward transverse inclination provided to the cross section of the carriage way at horizontal curved portion of a road is called as super-elevation.	01 M each
Q.1	d) Ans:-	<i>Define Flakiness Index and Elongation Index.</i> Flakiness Index: - The flakiness index is the percentage by weight of particles whose least dimension (thickness) is less than three-fifths (0.6) of their mean dimension. Elongation Index: - The elongation index is the percentage by weight of particles whose	01 M each



		greatest dimension (length) is greater than one fifth times (1.8) their mean dimension.	
Q.1	e) Ans:-	List various types of curves provided on Hill Roads. Types of curves provided on hill roads: - 1) Hair pin curves 2) Salient curves 3) Re-entrant curves	02 M
Q.1	f) Ans:-	State the necessity of providing catch water drain in Hill Roads. 1) Catch water drains are provided to collect excessive rainwater in heavy rainfall regions i.e. in case of hill roads. 2) These drains are useful to avoid large water flow reaching to hill road surface. 3) It helps to avoid landslides in hill roads. 4) It may be excavated natural rock section on hill top side which avoids erosion of soil along hill road.	01 M each (any two)
Q.1	g) Ans:-	State two causes of Landslides. 1) Due to seepage pressure of percolating ground water. 2) Due to increase load of traffic. 3) Undermining caused by erosion. 4) Due to earthquakes. 5) Due to vibration, faults are formed in bedding plans of the strata. Due to failure of a retaining wall or breast wall	01 M each (any two)
Q.2		Attempt any THREE of the following.	(12)
Q.2	a) Ans:-	Classify the roads according to Nagpur Road Plan. According to Nagpur Road Plan, Roads in India are classified into the following categories:- 1) National Highways (N.H.): - The main highways running through the length and breadth of the country connecting major ports, foreign highways, capitals of states, large industrial and tourist places etc. are known as National Highway. 2) State Highways (S.H.): - The highways linking district headquarters and important cities within the state or connecting them with National Highways or with Highways of the neighboring states are known as State Highways. 3) Major District Roads (M.D.R.): - The important roads within a district serving areas of production and markets and connecting these places with each other or with the main highways are known as Major District Roads. 4) Other District Roads (O.D.R.): - The roads serving rural areas of production and providing them with outlet to market centers, Tehsil headquarters, block development headquarters, railway stations, etc. are known as Other District Roads. 5) Village Roads (V.R.): - The roads connecting villages or group of villages with each other or with the nearest road of higher category are known as Village Roads.	04 M
Q.2	b) Ans:-	Define Design Speed. Give four factors affecting Design Speed. The maximum safe speed of vehicle assumed for geometrical design of a highway is known as Design Speed. Factors affecting design speed:- 1) Class and condition of the road surface 2) Nature, intensity and type of traffic 3) Type of curve along the road 4) Sight distance required 5) Topography of the area	02 M 02 M 1/2 M (any four)


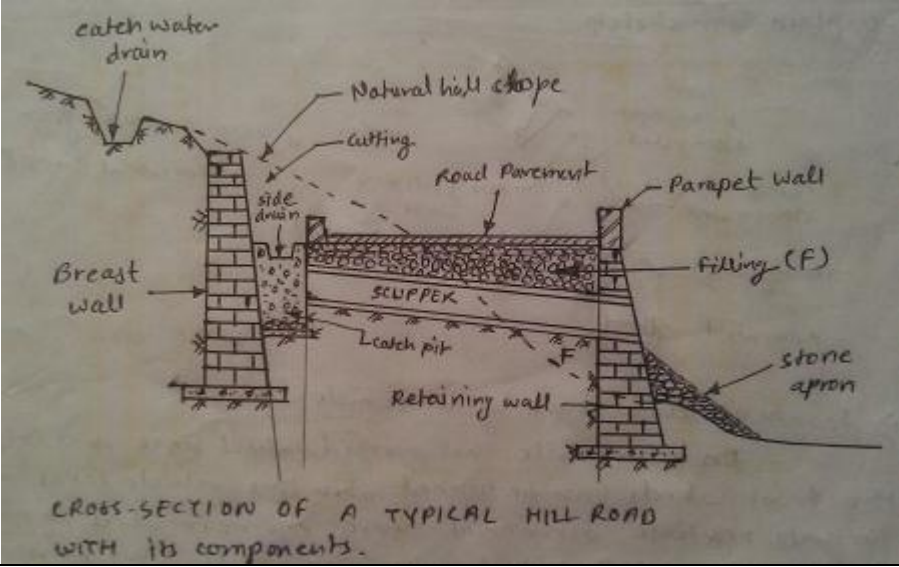


		6) Importance of highway.	
Q.2	c) Ans:-	<p>Define gradient. Explain types of gradient.(Any Two)</p> <p>Gradient:-It is the rate of rise or fall of ground with respect to horizontal, is known as <i>Gradient</i> OR The longitudinal slope provided along the length of road, is known as <i>Gradient</i>.</p> <p>Types of gradient –</p> <ol style="list-style-type: none">1) Ruling gradient – The gradient which is commonly provided under normal condition is known as ruling gradient.2) Limiting gradient – The maximum gradient provided more than ruling gradient due to topography, is known as limiting gradient.3) Exceptional gradient – The gradient provided in extraordinary situation (very short length road) is known as exceptional gradient.4) Floating gradient – The gradient provided such that vehicle will move with constant speed without application of brakes or power, is known as floating gradient.5) Minimum gradient – The minimum value of gradient provided for removal of water, is known as minimum gradient.6) Average Gradient – The average of both maximum and minimum gradient can be considered as average gradient.	02 M 02 M (any two)
Q.2	d) Ans:-	<p>State and explain functions of Pavement Components.</p> <ol style="list-style-type: none">1) Seal coat: - The main functions of providing seal coat are to develop skid resistance of the surface, to make road surface waterproof and to increase the life of the road surface.2) Wearing course: - The functions of wearing course are to resist wear and tear and to provide adequate foot hold and avoid slipping or skidding of vehicles.3) Base course: - Base course forms a support to the wearing course. This course distributes the concentrated loads from the upper layer to the lower layer and withstands high shearing stress. It also provides some degree of flexibility to the pavement.4) Sub-base course: - This layer is laid on the natural layer down below and supports wearing surface and base. It is an intermediate layer and performs more or less the same functions as the base course.5) Sub-grade: - It is the last layer forming the foundation for the road pavement. It carries the entire load of the traffic and the pavement which rest on subgrade.	01 M each (any four)
Q.3		Attempt any THREE of the following :	(12)

<p>Q.3</p>	<p>(a) Ans.</p>	<p>Explain the construction procedure of Bituminous Road.</p> <p>The construction procedure of bituminous road is summarized as under:</p> <ol style="list-style-type: none"> 1) Preparation of sub-grade – The existing ground is made clean to remove dust and other unwanted particles using ordinary and steel brooms. A thin layer of bitumen is sprayed on this clean surface. 2) Preparation of base course – The hard stone aggregate of specified size is spread approximately along the width of road. These stones aggregate(metal) are then compacted using smooth wheel roller or vibratory roller of 6 ton to 10 ton capacity. Now a thin layer of bitumen as prime coat is spread manually or mechanically. 3) Application of surface dressing courses or preparation of bituminous base course (M.P.M) – The tack coat is spread manually or mechanically on prepared base course. Now course aggregate (metal) of size 40 mm to 60 mm is spread uniformly over the treaded base course and rolled with roller. The hot bitumen is spread over the layer of compacted course aggregate (metal) and key aggregates are spread over the bitumen layer followed by roller compaction as per the design camber. 4) Laying of wearing course and seal coat – The wearing surface is laid over one layer of surface course of bituminous mix. The final layer of wearing surface is applied over thin layer of seal coat followed by necessary compaction as per camber and gradient of road. 	<p style="text-align: right;">01 M</p> <p style="text-align: right;">01 M</p> <p style="text-align: right;">01 M</p> <p style="text-align: right;">01 M</p>
<p>Q.3</p>	<p>(b) Ans.</p>	<p>Explain Softening Point Test on Bitumen with neat sketch.</p> <p>Softening Point Test:</p> <p>The softening point test is conducted by Ring and Ball method in the laboratory as described below:</p> <div style="text-align: center;"> </div> <p>The test sample of the given bituminous material is put in the brass ring which is then suspended in liquid like water or glycerin at a given temperature as shown in above figure. After this a steel ball is placed upon the bitumen and the liquid is heated at a rate of 5° C per minute. The temperature at which the softened bitumen touches the metal base, placed at a specified distance below the ring is recorded as the softening point of the bitumen. The softening point so recorded is compared with the specified values and thus the suitability of the bitumen under test is decided for bituminous pavement construction.</p>	<p style="text-align: right;">01 M (for neat sketch)</p> <p style="text-align: right;">01 M (for labeling)</p> <p style="text-align: right;">02 M</p>



Q.3	(c) Ans.	State different types of Tar used in construction of Road with its suitability. The following are the types of Tar with their suitability. 1) RT1 – It is suitable for painting road pavements under exceptionally cold weather. 2) RT2 – It is suitable for painting road pavements under normal climatic conditions. 3) RT3 – It is suitable for surface painting and renewal coats, premixed top course and light carpets. 4) RT4 – It is suitable for premixed macadam in base course. 5) RT5 – It is suitable for grouting macadam.	04 M (1 M each – any four)
Q.3	(d) Ans.	Define Passenger Car Unit. Give factors affecting it. Passenger Car Unit (PCU) : Practically, the passenger car is considered as standard vehicle unit to convert the other vehicle classes and this unit is called 'Passenger Car Unit' or 'PCU'. Factors affecting PCU values: The PCU values of different vehicle classes depends upon following factors: 1) Dimensions of vehicles such as width and length. 2) Dynamic characteristics of vehicles such as power, speed, acceleration and braking. 3) Transverse and longitudinal gaps or clearance between moving vehicles which depends upon the speeds, driver characteristics and the vehicle classes at the adjoining spaces. 4) Traffic stream characteristics such as composition of different vehicle classes, mean speed and speed distribution of the mixed traffic stream and volume to capacity ratio. 5) Roadway characteristics such as road geometrics including gradient and curves, access controls, rural or urban road, presence of intersections and the type of intersections. 6) Regulation and control of traffic such as speed limit, one way traffic, presence of different traffic control devices etc.	02 M 02 M (any four) 1/2 M each
Q.4		Attempt any THREE of the following:	(12)
Q.4	(a) Ans.	List causes of Accident. Draw Collision diagram for Head –on-Collision. Causes of Road Accidents: The various causes of accidents may be listed as given below: 1) Due to Drivers: Excessive speed and rash driving, carelessness, violation of rules and regulation, failure to see or understand the traffic situation, sign or signal, temporary effects due to fatigue, sleep or effect of consuming alcohol. 2) Due to Pedestrians: Violating regulations, carelessness while using the carriageway meant for vehicular traffic. 3) Due to Passengers: Alighting from or getting into moving vehicles. 4) Due to Vehicle defects: Failure of brakes, steering system, or lighting system, tyre burst and any other defect in the vehicles. 5) Due to Road Condition: Slippery or skidding road surface, pot holes, ruts and other damaged conditions of the road surface, temporary obstruction to line of sight (caused by branch of tree or disabled vehicle) resulting in reduction in normal sight distance. 6) Due to Road Design: Defective geometric design like inadequate sight distance at horizontal or vertical curves, improper curve design, inadequate width of	02 M (any four) 1/2 M each

		<p>shoulders, improper lighting and improper traffic control devices.</p> <p>7) Due to Traffic Condition: Other vehicles of the traffic stream, such as a vehicle moving ahead getting involved in accident, presence of disabled vehicle on the roadway.</p> <p>8) Due to Weather: Unfavorable weather conditions like mist, fog, snow, dust, smoke or heavy rainfall which restrict normal visibility and render driving unsafe.</p> <p>9) Due to Animals: Stray animals on the road.</p> <p>10) Other causes: Incorrect signs or signals, gate of level crossing not closed when required, ribbon development, badly located advertisement boards or service stations etc.</p> <p>Collision Diagram for Head-on-Collision:</p> 	02 M
Q.4	(b) Ans.	<p>Explain preventive measures that can be taken to avoid landslides in hilly area.</p> <p>The preventive measures that can be taken to avoid landslide in hilly area:</p> <p>The land slide can not be prevented due to earthquakes, but land slides due to other causes can be prevented by taking the following measures:</p> <ol style="list-style-type: none"> 1) By providing efficient surface and cross drainage. 2) By providing sub-surface drains at foot of the hill slope to control seepage flow. 3) By providing benching to soil slope. 4) By reducing the angle of slope or providing breast walls and retaining walls. 5) By constructing buttress at toe of hill slopes. 6) By slope treatment to minimize the erosion and to improve the stability of hill slopes. This is done by turfing, stone pitching, cement grouting etc. 	04 M (any four) 01 M each
Q.4	(c) Ans.	<p>Draw a typical cross-section of Hill Road and label all component parts.</p> <p>The typical cross section of Hill Road with all component parts is as below:</p>  <p>CROSS-SECTION OF A TYPICAL HILL ROAD WITH its components.</p>	04 M (02 M for figure and 02 M for labeling)
Q.4	(d) Ans.	<p>State the functions of surface drainage and sub-surface drainage.</p> <p>Function of Surface drainage:</p>	

The function of Surface drainage is to drain the water from the pavement surface and the shoulders during the rains and to divert it to the road-side drains such that the entry of water into the pavement layers and the subgrade soil is minimized.

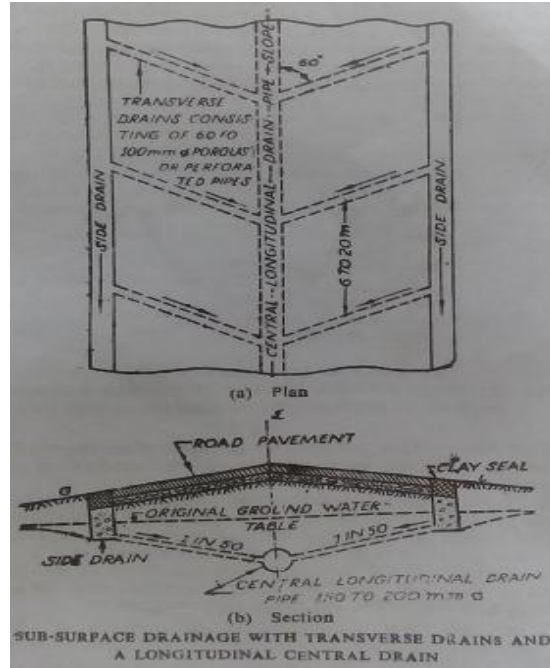
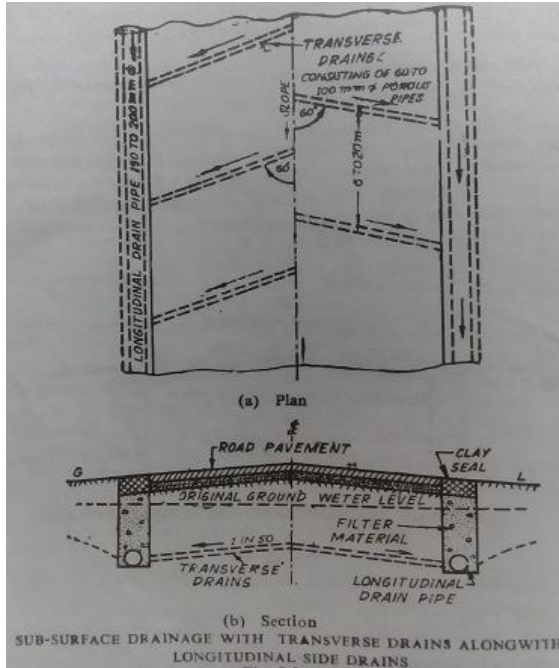
Function of Sub-surface drainage:

The function of sub-surface drainage is to intercept the 'seepage flow' of water and divert the same away from the roadway to the nearest water course. The sub-surface drainage system also helps in lowering the ground water level well below the subgrade and in controlling the capillary rise of water.

02 M

02 M

Q.4 (e) **Draw a neat sketch (Plan & Section) of Longitudinal drain and Cross drain.**
Ans. The Plan and section of Longitudinal drain and Cross drain is as given below:



OR

04 M
(02 M for figure and 02 M for labeling)

Q.5 **Attempt any TWO of the following:**

(12)

Q.5 (a) **Calculate the Stopping Sight Distance for two way traffic in a Single Lane Road. The design speed of the Road is 60 kmph. Assume Reaction time of the driver as 2.5 sec and Co-efficient of friction as 0.6. Brake efficiency is 50%.**

Ans.

Given data:

$V = 60 \text{ Kmph}$

$t = 2.5 \text{ seconds}$

$f = 0.6$ and brake efficiency is 50%

As the brake efficiency is 50% the wheels will skid through 50% of the braking distance and rotate through the remaining distance. Therefore, the value of coefficient of friction developed (f) may be taken as 50% of the coefficient of friction,

i.e. $f = (50/100) \times 0.6 = 0.3$

$SSD = 0.278 V t + (V^2 / 254 f)$

$= (0.278 \times 60 \times 2.5) + (60^2 / (254 \times 0.3))$

$= 41.70 + 47.24$

$SSD = 88.94 \text{ m. for one way traffic.}$

SSD for Two Way traffic on single lane road = 2 x SSD for one way traffic

$= 2 \times 88.94 \text{ m}$

$= 177.88 \text{ m say } 178 \text{ m.}$

01 M

01 M

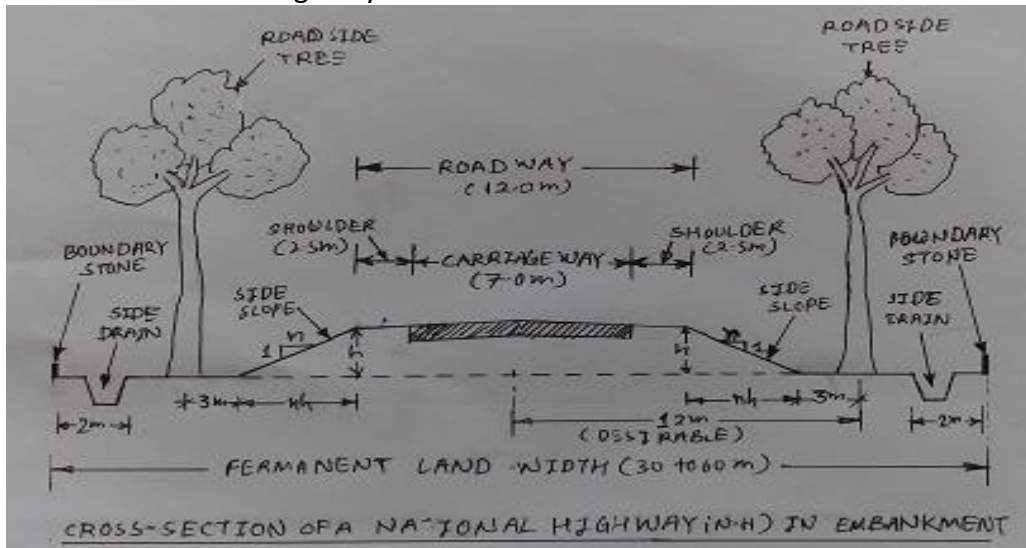
02 M

01 M

01 M

Q.5 (b) **Draw a neat cross-section of National Highway in Embankment.**

Ans. Cross-section of National Highway in Embankment:



02 M for figure
02 M for labeling
02 M for dimensions

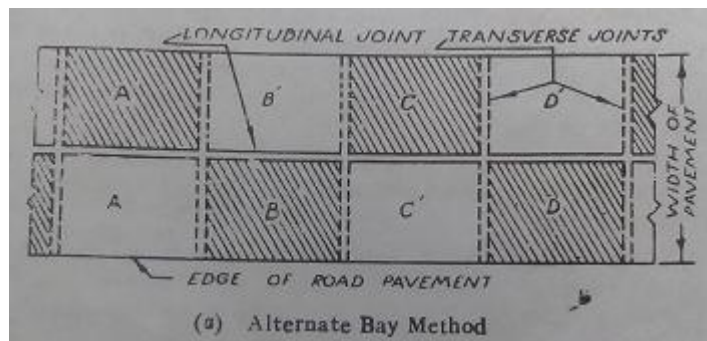
Q.5 (c) **State the methods of construction of Cement Concrete Road. Explain any one method.**

Ans. **Methods of construction of C.C. Road:** There are the following two methods of construction of Cement Concrete Road –

- (1) Alternate bay method.
- (2) Continuous construction method.

Explanation:

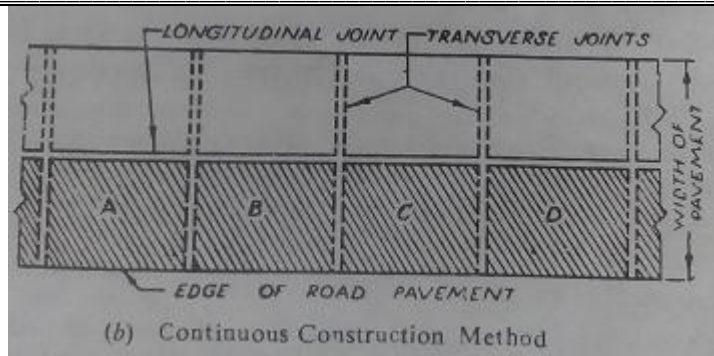
(1) Alternate bay method: In this method of construction, bays or slabs are constructed in alternate succession (ABCE), leaving the intermediate bays (A'B'C'D') as shown in figure. These intermediate bays are constructed after a gap of at least one week if ordinary Portland cement is used and two days in the case when rapid hardening cement is used. This method is practicable and found useful when the proposed width of pavement is more than 4.5 m. This method provides additional working convenience for laying of slabs.



(2) Continuous Construction method: In this method of construction, all the bays or slabs (ABCD) of strip are constructed continuously without any break as shown in figure. In this method, construction joints are, however, provided when the day's work is not ended at the specified joint. In addition to these, construction joints, dummy joints are also provided at 5 m. intervals in the transverse direction to check the planes of weakness and to control cracking. This method is generally preferred as compared to alternate bay method because of its main advantage of construction of half the pavement width at a time. Thus, the essential traffic can be diverted on the other half of the road.

02 M
(01 M each)

04 M for any one method
(02 M for explanation and 02 M for figure)



Q.6 **Attempt any TWO of the following:** (12 M)

Q.6 (a) **Draw Traffic Signs for**
Ans. (i) **Left Turn Prohibited**
(ii) **No Parking**
(iii) **Speed Limit – 60 Kmph**
(iv) **Width Limit – 2 m**
(v) **Narrow Bridge**
(vi) **Compulsory Ahead or Turn Right**

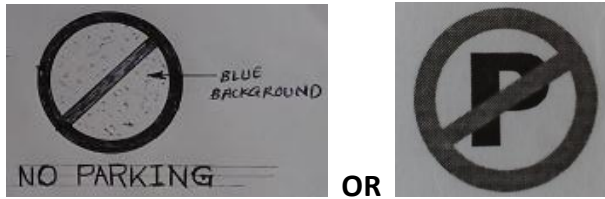
The traffic signs are below:

(i) Left Turn Prohibited –



01 M

(ii) No Parking: -



01 M

(iii) Speed Limit – 60 Kmph:



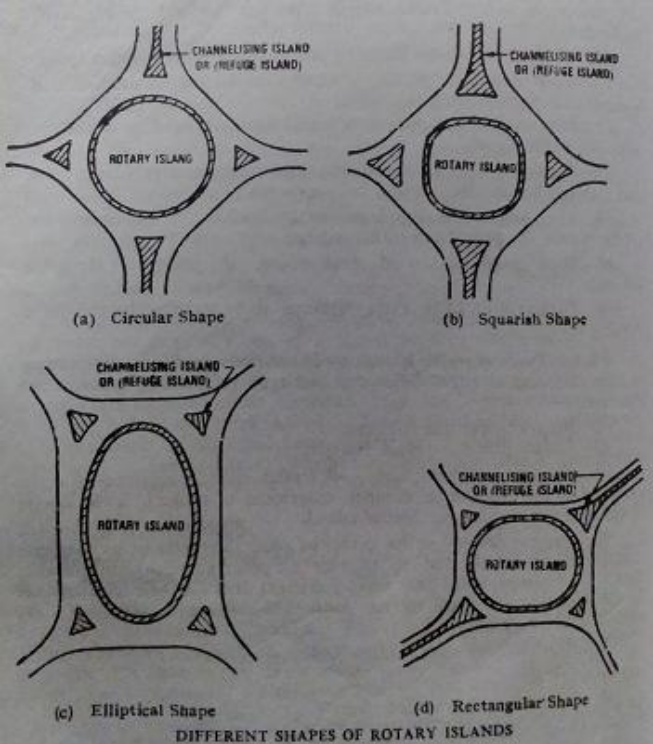


01 M

(iv) Width Limit – 2 m:



01 M

		<p>(v) <u>Narrow Bridge:</u></p>  <p>(vi) <u>Compulsory Ahead or Turn Right:</u></p> 	<p>01 M</p> <p>01 M</p>
<p>Q.6</p>	<p>(b) Ans.</p>	<p>Explain Rotary Island (Traffic Island) with a neat sketch.</p> <p>Rotary Island or Traffic Island:</p> <p>The raised platforms of suitable shapes built on the road intersections are called traffic islands or rotary island.</p> <p>A rotary intersection or traffic rotary is an enlarged road intersection where all converging vehicles are forced to move round a large central island in one direction before they can weave out of traffic flow into their respective directions radiating from the central island.</p> <p>The main objects of providing a rotary are to eliminate the necessity of topping even for crossing streams of vehicles and to reduce the area of conflict. The crossing of vehicles is avoided by allowing all vehicles to merge into the streams around the rotary and then to diverge out to the desired radiating road.</p>  <p style="text-align: center;">DIFFERENT SHAPES OF ROTARY ISLANDS</p>	<p>02 M</p> <p>02 M</p> <p>02 M for any one figure from (a), (b), (c) or (d)</p>



Q.6	(c)	<p>Justify the remedial measures for following defects :</p> <p>(i) Formation of pot holes in case of WBM roads.</p> <p>(ii) Formation of ruts in case of earthen roads.</p> <p>(iii) Bitumen bleeding in case of bituminous roads.</p> <p>Ans. The cross section of hill road is shown below:</p> <p>(i) Formation of pot holes in case of WBM roads : The pot holes should be patched up by.</p> <p>(1) Cutting the defective area to rectangular shape and removing the loose stones up to the affected depth.</p> <p>(2) Filling up the prepared area with coarse aggregate of the same size.</p> <p>(3) Watering and compaction by rammer or road roller.</p> <p>(4) Application of wet soil binder to fill up the interstices and compaction.</p> <p>(ii) Formation of ruts in case of earthen roads : The remedial measure is quite simple.</p> <p>(1) Cleaning the affected area and light watering.</p> <p>(2) Filling the rut using selected earth.</p> <p>(3) Watering and compaction by rolling.</p> <p>(4) Checking of camber for efficient drainage.</p> <p>(iii) Bitumen bleeding in case of the bituminous roads : If the surfacing consists of excessive bitumen, the surface become slippery during rainy season and bleed during hot weather. Bleeding normally occurs just after the construction of the road. For bleeding the Surface treatment is remedy. Bleeding can easily be corrected by spreading a layer of dry coarse sand in a thickness varying 5 mm to 10 mm and rolling the surface.</p>	02 M 02 M 02 M
-----	-----	--	------------------------------

22302

11920

3 Hours / 70 Marks

Seat No.

--	--	--	--	--	--	--	--	--

- Instructions :**
- (1) All Questions are *compulsory*.
 - (2) Answer each next main Question on a new page.
 - (3) Illustrate your answers with neat sketches wherever necessary.
 - (4) Figures to the right indicate full marks.
 - (5) Assume suitable data, if necessary.

Marks

1. Solve any FIVE :

5 × 2 = 10

- (a) State any four modes of Transportation.
- (b) Classify the roads according to Nagpur Road Development plan.
- (c) State any two requirements of a Ideal road alignment.
- (d) Define traffic volume and traffic density.
- (e) Enlist any four types of Traffic Island.
- (f) State any two causes of Landslides.
- (g) State the types of drainage system.

2. Solve any THREE :

3 × 4 = 12

- (a) Define gradient and state any four types of gradient.
- (b) Define :
 - (i) Stopping Sight Distance
 - (ii) Overtaking Sight Distance
- (c) Draw a neat sketch of std. C/s of National Highway in embankment.
- (d) State any two merits and demerits of WBM road.

[1 of 4]

P.T.O.

3. Solve any THREE :**3 × 4 = 12**

- (a) Write the procedure of construction of cement concrete pavement showing it's components.
- (b) Draw C/S of typical flexible pavement & label it's components.
- (c) Draw road sign for,
 - (i) Load limit
 - (ii) Keep left
 - (iii) Right hand curve
 - (iv) Hospital
- (d) State the difference between alignment of hill roads and alignment of plain roads.

4. Solve any THREE :**3 × 4 = 12**

- (a) State any four preventive measures of Landslides in hilly roads.
- (b) Draw labelled sketches of side drains along hill roads.
- (c) State any four causes of failure of rigid pavement.
- (d) Prepare a chart showing schedule of maintenance operation from October to March for bituminous road.
- (e) Justify the remedial measures for the following defects in earthen road :
 - (i) Formation of dust during dry weather
 - (ii) Growth of vegetation inside drains & their silting up.

5. Solve any TWO :**2 × 6 = 12**

- (a) Enlist three types of curves provided on hill roads. Draw neat sketch of them.
- (b) Calculate the design speed of a vehicle on a horizontal curve having radius of 100 m. with permissible super elevation of 7%. Consider Coeff. of friction 0.18.
- (c) State the requirement of good quality material which plays the major role in highway construction.

6. Solve any TWO :**2 × 6 = 12**

- (a) Write the procedure of construction of WBM road with neat sketch showing various components.
 - (b) Explain the Divisional Island with neat sketch.
 - (c) Draw the Collision diagram for,
 - (i) Head on Collision
 - (ii) Rear end Collision
 - (iii) Side Sweep
-



WINTER-19 EXAMINATION

MODEL ANSWER

22302**Subject: Highway Engineering****Subject Code-**

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors etc... should not be given more Importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.

Que. No.	Sub Que.	Answer	Marking Scheme	Total Marks
1		Solve any FIVE:		10
	a) Ans.	State any four modes of transportation Four modes of transportation are: a) Roadways or Highways b) Railways c) Waterways d) Airways.	1/2 mark each	2
	b) Ans.	Classify the roads according to Nagpur Road Development plan. According to Nagpur plan, roads are classified as: 1) National Highway (NH) 2) State Highway (SH) 3) Major District Road (MDR) 4) Other District Road (ODR) 5) Village Road (VR)	2	2
	c) Ans.	State any two requirements of a Ideal road alignment a) Crossing: The provision of railway and road crossing should be properly studied. Dangerous road and rail crossing should be avoided. b) Proper drainage: The provision of proper and sufficient drainage is necessary for the stability of the road and hence the road alignment should take into consideration factors like rain water, ground water etc... c) Availability of local materials: For reducing the cost of construction and maintenance, it is necessary to have easy availability of natural materials like sand, gravel, soil etc...	2 marks (any two)	2



MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

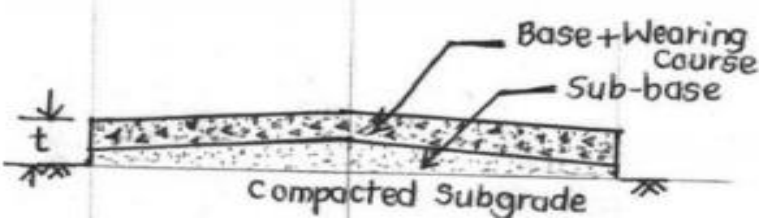
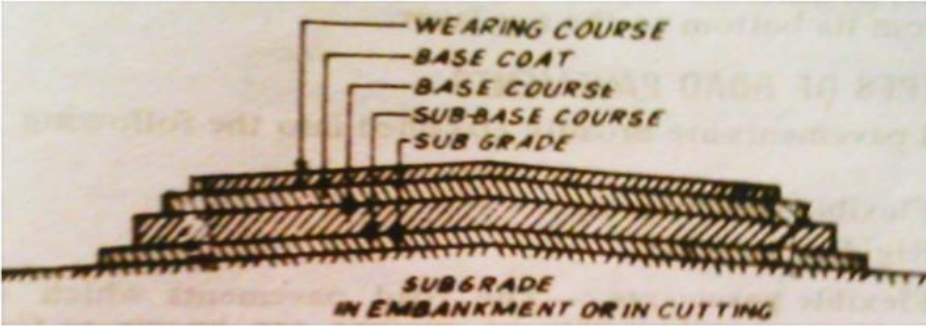
(Autonomous)
(ISO/IEC - 27001 - 2013 Certified)





1	<p>d) The road should have good visibility at night and other climatic conditions e) The alignment should be such that sufficient safety should be there while travelling on the road f) The road should connect important points like school, places of tourist's importance etc... g) The road should be such that the slope and curves are easy. h) It is desirable to have short distance between the two terminal stations. i) It should provide economy in the cost of construction and maintenance. j) The alignment should be safe for traffic operation. k) The alignment should provide maximum utility by connecting important towns and group of villages. l) The alignment should pass through regions of natural beauty and scenery to have good natural aspects</p>		
	<p>d) Define traffic volume and traffic density Ans. Traffic Volume: It is the number of vehicles moving in a specified direction on a given lane or roadway that pass a given point or cross section during specified unit of time Traffic Density: It is the number of vehicles occupying a unit length of lane of roadway at a given instant usually expressed as vehicles per km.</p>	1 1	2
	<p>e) Enlist any four types of traffic islands Ans. a) Divisional Island. b) Pedestrians Loading Islands c) Channelized Intersections d) Roundabouts or Rotaries</p>	½ mark each	2
	<p>f) State any two causes of landslides Ans. Causes of Landslides: a) Increase in the water content of the soil b) Improper drainage system c) Increase in the weight due to accumulation of snow and external loads due to traffic d) Undermining caused by erosion or extraction e) Vibration and shocks caused by blasting or earthquakes f) Hair cracking due to alternate swelling and shrinkage of the soil mass g) Formation of faults in bedding planes of strata due to vibrations. h) Due to seepage pressure of percolating ground water i) Due to failure of breast wall</p>	1 mark each (Any two)	2
	<p>g) State the types of drainage system Ans. In plain areas, a) Surface Drainage b) Sub-surface Drainage Surface Drainage: Side drains, Catch water basin, Inlet Sub surface: Cross Drains, lateral drain, longitudinal drain, transverse drain OR In Hilly areas, a) Surface Drainage b) Sub-surface Drainage a) Surface Drainage: Side drains, catch water drain b) Sub surface drainage: Cross drains</p>	2 OR 2	4



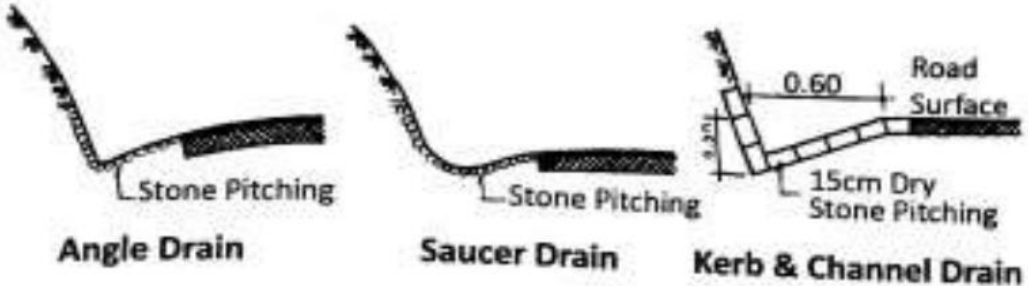
2		Solve any THREE :		12
	a) Ans.	<p>Define gradient and state any four types of gradient. The rate of rise and fall along the length of road w.r.t. horizontal surface is called as Gradient.</p> <p style="text-align: center;">OR</p> <p>The longitudinal slope provided along the length of road, is known as Gradient.</p> <p>Types 1) Ruling gradient 2) Limiting gradient 3) Exceptional gradient 4) Average gradient 5) Floating gradient 6) Minimum gradient</p>	2 ½ mark each (Any four)	4
	b) Ans.	<p>Define i) Stopping Sight distance ii) Overtaking sight distance i) Stopping Sight Distance: SSD may be defined as the length of highway required to bring a vehicle to stop at various design speeds when the eye of the driver is 1200mm above the pavement and the object causing the stop is 150mm above the pavement.</p> <p style="text-align: center;">Or</p> <p>The driver of the vehicle should be able to see clearly at least a certain portion of the road length to avoid collision or accident. This absolute minimum length required for this purpose is known as Stopping Sight Distance</p> <p>ii) Overtaking Sight Distance: OSD may be defined as 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.</p>	1 1	4
2	c) Ans.	<p>Draw a neat sketch of std. C/s of National Highway in embankment. Cross-section of National Highway in Embankment:</p> <p style="text-align: center;">CROSS-SECTION OF A NATIONAL HIGHWAY (N.H.) IN EMBANKMENT</p>	2 marks for sketch 2 marks for labeling	4



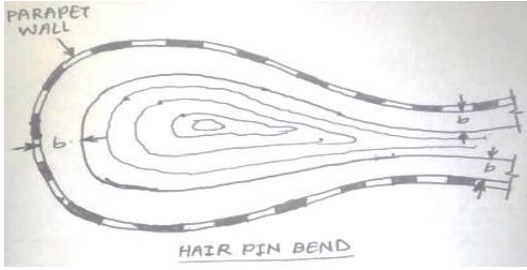
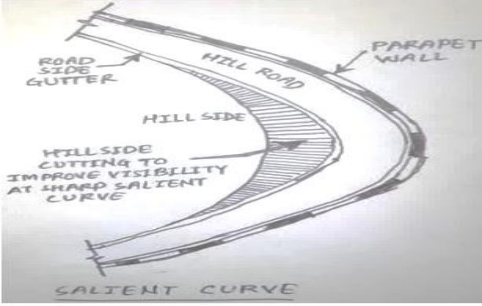
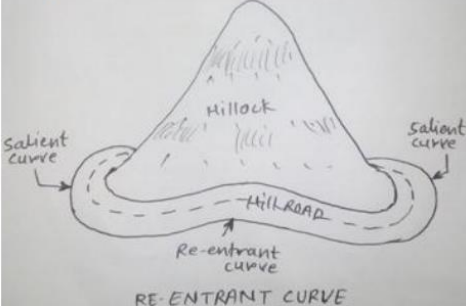
	<p>d) State any two merits and demerits of WBM road.</p> <p>Ans. Merits of WBM roads: 1) If in good condition, it can take a composite traffic of about 900 tonnes per lane per day 2) If WBM surfacing is maintained properly, it is found to have good service for a long-time. 3) Their initial cost is low. 4) They make use of the locally available materials.</p> <p>Demerits of WBM: 1) The maintenance cost is more. 2) If not maintained properly, then it causes inconvenience and danger to traffic. 3) They are permeable to rain water and it leads to the softening and yielding of materials 4) Life is less</p>	<p>2 (Any two)</p> <p>2 (Any two)</p>	<p>4</p>
<p>3</p>	<p>Solve any THREE:</p>		<p>12</p>
	<p>a) Write the procedure of construction of cement concrete pavement showing its components.</p> <p>Ans. Construction procedure of Concrete Roads:</p> <ol style="list-style-type: none"> 1) Preparation of subgrade by proper compaction 2) Provision of sub base to support subgrade 3) Placing of forms i.e. Steel channels 4) Batching and mixing of materials in plant 5) Transportation and placing of concrete through RMC vehicle 6) Compaction of poured concrete using vibrators 7) Floating of concrete using steel beam 8) Brooming of concrete surface using steel brush 9) Edging of concrete for obtaining sharp edges 10) Curing of road surface by ponding method 11) Filling of joints using joint sealers 12) Opening of traffic after cleaning 	<p>3</p> <p>1</p>	<p>4</p>
	<p>b) Draw C/S of typical flexible pavement & label its components</p> 	<p>4</p>	<p>4</p>

3	<p>c) Ans.</p>	<p>Draw road sign for,</p> <p>i) Load limit ii) Keep left iii) Right hand curve iv) Hospital</p> <p>i) Load Limit:</p>  <p>ii) Keep Left</p>  <p>or</p> <p>iii) Right hand Curve</p>  <p>iv) Hospital</p>  <p>or</p>	1 mark each	4																
	<p>d) Ans.</p>	<p>State the difference between alignment of hill roads and alignment of plain roads</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%; text-align: center;">Alignment of hill roads</th> <th style="width: 50%; text-align: center;">Alignment of plain roads</th> </tr> </thead> <tbody> <tr> <td>1. Sharp curves are to be provided</td> <td>1. Sharp curves are not to be provided</td> </tr> <tr> <td>2. Cost of construction is more</td> <td>2. Cost of construction is comparatively less</td> </tr> <tr> <td>3. Proper care has to be taken for drainage</td> <td>3. Drainage does not cause that much problem as compared to hill roads</td> </tr> <tr> <td>4. Stability is more important due to problem of landslides</td> <td>4. There is not much problem of landslides.</td> </tr> <tr> <td>5. Here, more cutting and filling takes place</td> <td>5. Comparatively, less cutting and filling takes place</td> </tr> <tr> <td>6. Slope/ gradient is more</td> <td>6. Slope/Gradient is less</td> </tr> <tr> <td>7. Alignment is difficult</td> <td>7. Alignment is easy</td> </tr> </tbody> </table>	Alignment of hill roads	Alignment of plain roads	1. Sharp curves are to be provided	1. Sharp curves are not to be provided	2. Cost of construction is more	2. Cost of construction is comparatively less	3. Proper care has to be taken for drainage	3. Drainage does not cause that much problem as compared to hill roads	4. Stability is more important due to problem of landslides	4. There is not much problem of landslides.	5. Here, more cutting and filling takes place	5. Comparatively, less cutting and filling takes place	6. Slope/ gradient is more	6. Slope/Gradient is less	7. Alignment is difficult	7. Alignment is easy	1 mark each (Any four)	4
Alignment of hill roads	Alignment of plain roads																			
1. Sharp curves are to be provided	1. Sharp curves are not to be provided																			
2. Cost of construction is more	2. Cost of construction is comparatively less																			
3. Proper care has to be taken for drainage	3. Drainage does not cause that much problem as compared to hill roads																			
4. Stability is more important due to problem of landslides	4. There is not much problem of landslides.																			
5. Here, more cutting and filling takes place	5. Comparatively, less cutting and filling takes place																			
6. Slope/ gradient is more	6. Slope/Gradient is less																			
7. Alignment is difficult	7. Alignment is easy																			



4	Solve any THREE		12	
a) Ans.	<p>State any four preventive measures of landslides in hilly roads</p> <ol style="list-style-type: none"> By providing proper and effective drainage system to intercept and divert seeping water By constructing buttress at toe and providing retaining structures By providing slopes and their treatment to minimize the erosion By providing soil stabilization By reducing the angle of slopes By stone pitching. By providing nets. Chemical treatment. Growth of vegetation on the slopes. 	<p>1 mark each (Any four)</p> <p>4</p>		
b) Ans.	<p>Draw labeled sketches of side drains along hill roads.</p>  <p>The diagrams show three types of side drains: 1. Angle Drain: A cross-section showing a slope with stone pitching at the toe. 2. Saucer Drain: A cross-section showing a saucer-shaped drain with stone pitching. 3. Kerb & Channel Drain: A cross-section showing a channel with a 0.60m width and 15cm high stone pitching on the side.</p>	<p>3 marks each and 1 mark for labelling</p> <p>4</p>		
c) Ans.	<p>State any four causes of failure of rigid pavement</p> <ol style="list-style-type: none"> Defective drainage system may lead to failures in rigid pavements such as mud pumping Use of nondurable materials which start deteriorating during weathering cycles. Improper alignment of dowel bars may lead to stress concentration and cracking near the joints. Defects in construction method and quality control during construction. Increase in the magnitude of wheel loads and the number of load repetitions, exceeding the design values. Structural inadequacy of the pavement structure Inadequate compaction of embankment or subgrade or settlement of embankment foundation itself, which could result in settlement of the supporting layers of the rigid pavement 	<p>1 mark each (Any four)</p> <p>4</p>		
d) Ans.	<p>Prepare a chart showing schedule of maintenance operation from October to March for bituminous road.</p> <table border="1" data-bbox="235 1596 1291 1890"> <tr> <td data-bbox="235 1596 584 1890">October to December:</td> <td data-bbox="584 1596 1291 1890"> <ol style="list-style-type: none"> Repairing of patch works Renewal of coats Repairing of damages caused by rains Repairing of scours in culverts and cleaning of silts if any Attending road signs, kilometer stones, boards etc. </td> </tr> </table>	October to December:	<ol style="list-style-type: none"> Repairing of patch works Renewal of coats Repairing of damages caused by rains Repairing of scours in culverts and cleaning of silts if any Attending road signs, kilometer stones, boards etc. 	<p>2</p> <p>4</p>
October to December:	<ol style="list-style-type: none"> Repairing of patch works Renewal of coats Repairing of damages caused by rains Repairing of scours in culverts and cleaning of silts if any Attending road signs, kilometer stones, boards etc. 			



		January to March	i) Repairing of patchwork ii) Repairing and inspection of gang huts iii) Renewal and improvement works	2	
4	e)	Justify the remedial measures for the following defects in earthen road: i) Formation of dust during dry weather ii) Growth of vegetation inside drains and their silting up		1 mark each (Any two)	4
	Ans.	i) Formation of dust during dry weather: The dust nuisance may be remedied by the following methods: Frequent sprinkling of water Treatment with calcium chloride Use of other dust palliatives Use of other material like tar, oil etc... ii) Growth of vegetation inside drains and their silting up: The growth of vegetation inside drains should be regularly cleaned either manually or by using machines in order to increase the capacity of the flowing water in the drain. Silting up of weeds, plants, bushes etc. causes obstruction in the flow of water.			
5		Solve any TWO:			12
	a)	Enlist three types of curves provided on hill roads. Draw neat sketch of them		1	6
	Ans.	The three types of curves in hill roads are- a) Hair –Pin Curves b) Salient Curves c) Re-entrant			
		  		5 (4 marks for sketch one mark for labelling)	
		(Note: All the above three diagrams are to be drawn)			



	<p>b)</p> <p>Ans.</p>	<p>Calculate the design speed of a vehicle on a horizontal curve having radius of 100m. with permissible super elevation of 7%. Consider co efficient of friction 0.8.</p> <p>Super elevation = $7\% = \frac{7}{100} = 0.07$.</p> <p>R = 100 m.</p> <p>f = 0.8.</p> $e + f = \frac{V^2}{127 R}$ $0.07 + 0.18 = \frac{V^2}{127 \times 100}$ $V^2 = (0.07 + 0.18) \times (127 \times 100)$ $= (0.25) \times (12700)$ $= 3175$ $V = \sqrt{3175} = 56.34 \text{ km/hr.}$	<p>1</p> <p>1</p> <p>2</p> <p>2</p>	
<p>5</p>	<p>c)</p> <p>Ans.</p>	<p>State the requirement of good quality material which plays the major role in highway construction</p> <p>The materials which plays major role in highway construction are:</p> <ol style="list-style-type: none"> Soil Bitumen Cement Stone Concrete Sand <p>Requirements:</p> <p>a) Soil:</p> <ol style="list-style-type: none"> It should be clean and coarse. It should be free from any organic or vegetable matter; It should be chemically inert. It should not contain salts which attract moisture from the atmosphere. It should be well graded, i.e., it should contain particles of various sizes in suitable proportions. It should be strong and durable. It should be clean and free from coatings of clay and silt. <p>b) Bitumen:</p> <ol style="list-style-type: none"> The bitumen should not be highly temperature susceptible During the hottest weather the mix should not become too soft or unstable During cold weather the mix should not become too brittle causing cracks. The viscosity of the bitumen at the time of mixing and compaction should be adequate. This can be achieved by use of cutbacks or emulsions of suitable grades or by heating the bitumen and aggregates prior to mixing. 	<p>3 marks each (for any three type of materials)</p>	<p>6</p>



v) There should be adequate affinity and adhesion between the bitumen and aggregates used in the mix.

c) Cement:

- i) The color of the cement should be greenish grey.
- ii) Cement should give a cool feeling when hand is thrust into the cement bag
- iii) Cement should give smooth feeling when rubbed between two fingers
- iv) When cement is thrown into a bucket of water it should float for some time and then sink
- v) There should not be presence of lumps

d) Stone:

- i) It should be descent in appearance and have uniform colour.
- ii) It should be durable i.e. it should resist atmospheric action and should be long lasting
- iii) For a good stone, the crushing strength should be more than 100 N/mm^2
- iv) Stones should be such that they can be dressed easily and economically.
- v) For a good building stone, the specific gravity should be more than 2.7
- vi) The percentage of water absorption of water by weight after 24 hours should not exceed 60%.
- vii) Minerals in stones should be such that it should catch fire easily.
- viii) Stones should be well seasoned before use.

e) Concrete:

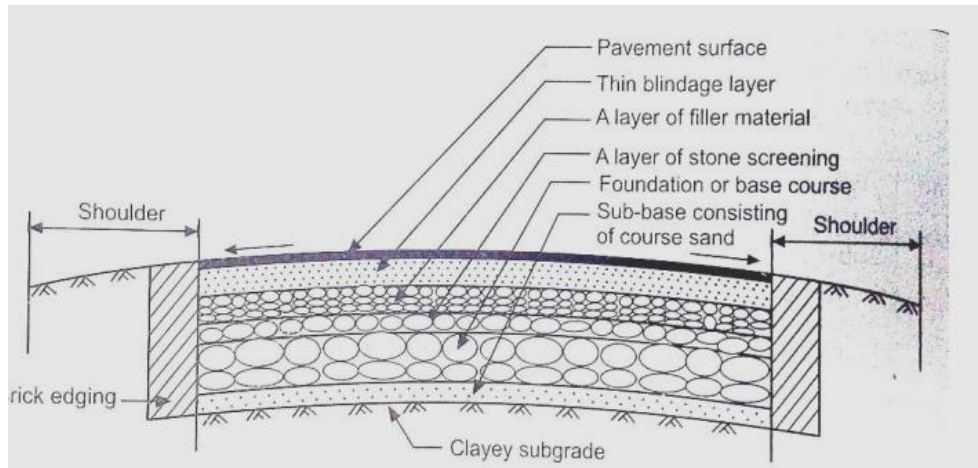
- i) It should have good workability so that it can be easily handled and placed in position.
- ii) It should be dense and compact.
- iii) It should have enough compressive strength.
- iv) It should be durable.
- v) It should be resistant to fire.
- vi) It should be impermeable.
- vii) It should form hard surface capable of resisting abrasion.
- viii) It should have minimum shrinkage.
- ix) It should be economical.

f) Sand:

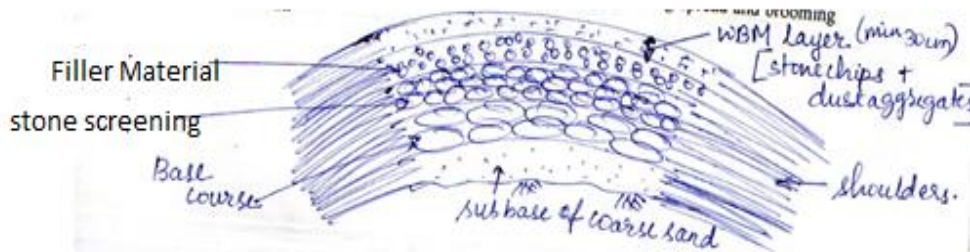
- i) It should be clean and coarse.
- ii) It should be free from any organic or vegetable matter;
- iii) It should be chemically inert.
- iv) It should contain sharp, angular, coarse and durable grains.
- v) It should not contain salts which attract moisture from the atmosphere.
- vi) It should be well graded, i.e., it should contain particles of various sizes in suitable proportions.
- vii) It should be strong and durable. It should be clean and free from coatings of clay and silt.



6	Solve any TWO		12
	<p>a) Write the procedure of construction of WBM road with neat sketch showing various components</p> <p>Ans. Construction Procedure:</p> <p>a) Preparation of Foundation: The foundation for receiving the layer of WBM may be either the sub-grade or sub-base or base course. The depressions and pot holes on the existing road surface are filled up and the corrugations are removed by scarifying and reshaping the surface to the required grade and reshaping camber as necessary.</p> <p>b) Spreading of coarse aggregate: The coarse aggregate is spread uniformly on the prepared base. The WBM course is normally constructed to compacted thickness of 7.5cm.</p> <p>c) Rolling: After spreading the coarse aggregates properly, compaction is done by a three wheeled power roller of capacity 6 to 10 tonnes or alternatively by an equivalent vibratory roller; the weight of the roller depends on the type of coarse aggregates. The rolling is done until adequate compaction is achieved.</p> <p>d) Application of Screenings: After the coarse aggregates are rolled adequately, the dry screenings are applied gradually over the surface to fill the interstices (Voids) in three or more applications. Dry rolling is continued as the screenings are being spread and brooming is carried out.</p> <p>e) Sprinkling and Grouting: After the application of screenings, the surface is sprinkled with water, swept and rolled. Wet screenings are swept into the voids using hand brooms. Additional screenings are applied and rolled till the coarse aggregates are well bonded and firmly set.</p> <p>f) Application of binding materials: After the application of screening and rolling, binding material is applied at a uniform and slow rate at two or more successive thin layers. After each application of binding material, the surface is copiously sprinkled with water and wet slurry swept with brooms to fill the voids. This is followed by rolling with a 6 to 10 tonnes roller and water is applied to the wheels to wash down the binding material that sticks to the roller. When crushable type screenings like moorum or gravel are used, there is no need to apply binding materials, except in the surface course.</p> <p>g) Setting and Drying: After final compaction, the WBM course is allowed to set over night. On the next day, the hungry spots are located and are filled with screenings and binding material, lightly sprinkled with water and rolled. No traffic is allowed till WBM layer sets and dries out.</p>	4	6



OR



2

b)
Ans.

Explain the Divisional Island with neat sketch

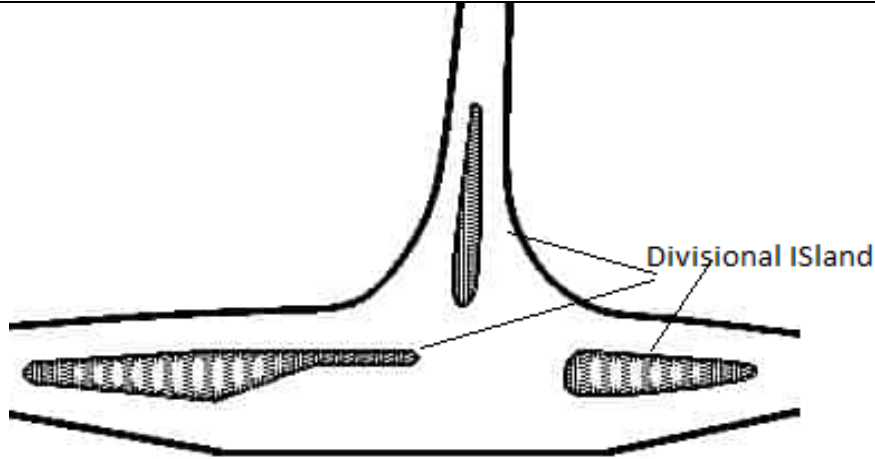
These types of Island are constructed to separate the traffic from opposite directions in a highway having four or more lanes. Thus, by providing such type of island the highway is divided into two one way roadways, eliminating head on collision and other accidents.

The width of such islands is more to avoid headlight glare during night driving.

The kerb should be high enough to prevent vehicles from entering into the islands

4

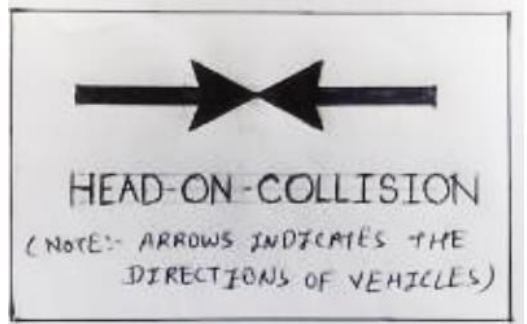
2



c) Draw the Collision Diagram for,
i) Head on collision
ii) Rear end collision
iii) Side Sweep

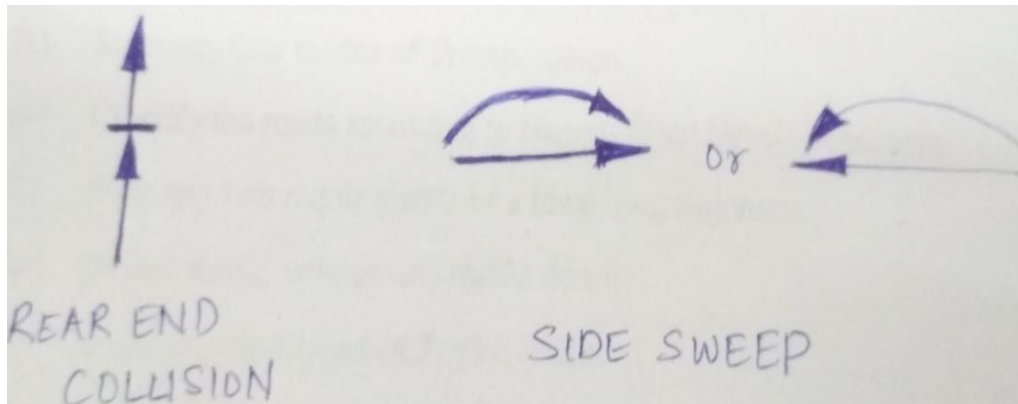
Ans.

i) Head on Collision:



ii) Rear end

iii) Side sweep



2 mark each

6

22302

21819

3 Hours / 70 Marks

Seat No.

--	--	--	--	--	--	--	--	--

- Instructions :**
- (1) All Questions are *compulsory*.
 - (2) Answer each next main Question on a new page.
 - (3) Illustrate your answers with neat sketches wherever necessary.
 - (4) Figures to the right indicate full marks.
 - (5) Assume suitable data, if necessary.
 - (6) Use of Non-programmable Electronic Pocket Calculator is permissible.
 - (7) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.
 - (8) Use of steam tables, logarithmic, Mollier's chart is permitted.

Marks

1. Attempt any FIVE of the following :

10

- (a) Classify roads as per Nagpur Plan.
- (b) Define : (i) Camber
(ii) Super-elevation
- (c) Enlist types of Gradients.
- (d) Define : (i) Road carriageway
(ii) Road shoulder
- (e) Define : (i) Traffic density
(ii) Traffic volume
- (f) State the necessity of Good drainage (2 points).
- (g) State classification of highway maintenance.

2. Attempt any THREE of the following :

12

- (a) Define alignment and state the requirement of an ideal road alignment.
- (b) State the necessity of providing extra widening on horizontal curves.
- (c) Explain the procedure for determining softening point of bitumen.
- (d) Define PCU and list four factors affecting passenger car unit.

[1 of 2]

P.T.O.

- 3. Attempt any THREE of the following : 12**
- (a) Calculate the safe stopping sight distance for a design speed of 50 kmph for a two way traffic in a single lane road.
Assume $f = 0.37$ and reaction time = 2.5 seconds.
 - (b) Explain the procedure for flakiness and elongation test on aggregate.
 - (c) Discuss the merits and demerits of bitumen road.
 - (d) List any four causes of Accidents.
- 4. Attempt any THREE of the following : 12**
- (a) Draw following road signs :
 - (i) Speed limit
 - (ii) No parking
 - (iii) Narrow Bridge
 - (iv) Hair pin bend left
 - (b) Draw a neat labelled sketch of National Highway in Embankment.
 - (c) Explain the types of hill road curve with neat sketch.
 - (d) Draw neat sketch of hill road showing its components.
 - (e) Draw neat sketch of subsurface drainage.
- 5. Attempt any TWO of the following : 12**
- (a) Design the rate of super elevation for a Horizontal Highway curve of radius 500 metres and speed 100 kmph. Assume suitable data.
 - (b) Describe stepwise construction procedure of cement concrete road by continuous bay method.
 - (c) Enlist different types of traffic island and explain any one in brief with neat sketch.
- 6. Attempt any TWO of the following : 12**
- (a) Describe stepwise construction procedure for water bound macadam roads.
 - (b) Discuss the types and causes of landslides with neat sketch.
 - (c) Discuss the causes of failure in flexible and rigid pavement.
-



SUMMER – 19 EXAMINATION

Subject Name: Highway Engineering (HEN)

Model Answer

Subject Code:

22302

Important Instructions to examiners:

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q. N.	Answer	Marking Scheme
Q.1		Attempt any FIVE of the following	10
	a)	Classify roads as per Nagpur Plan.	2M
	Ans:-	According to Nagpur plan, roads are classified as: 1) National Highway (NH) 2) State Highway (SH) 3) Major District Road (MDR) 4) Other District Road (ODR) 5) Village Road (VR)	
	b)	Define:	
	Ans:-	i) Camber: - The convexity provided to the surface of the carriage way is called camber OR The rise given to the center of carriage way above its edges on straight portion of a road is called camber.	1M
		ii) Super-elevation:- The inward transverse inclination provided to the cross section of the carriage way at horizontal curved portion of a road is called super elevation.	1M
	c)	Enlist types of Gradients.	
	Ans:-	Types of Gradient:- 1) Ruling gradient 2) Limiting gradient 3) Exceptional gradient 4) Average gradient 5) Floating gradient 6) Minimum gradient	½ M each (any four)
	d)	Define:	
	Ans:-	i) Road carriageway: - The portion of roadway constructed for movement of vehicular traffic is called carriageway. ii) Road shoulder: - The portion of the roadway between the outer edge of the	1M each



e) Ans:- f) Ans:- g) Ans:-	<p>pavement and inner edge of the side drain in cutting is called shoulder.</p> <p>Define :</p> <p>i) Traffic density: - Traffic density is the number of vehicles occupying a unit length of lane of roadway at a given instant.</p> <p>ii) Traffic volume: - It is defined as the survey of number of vehicles and pedestrian crossing section of road per unit during any selected period.</p> <p>State the necessity of Good drainage</p> <p>Necessity of good drainage:-</p> <p>1) Road drainage is necessary to collect surface water in side drains and to keep road surface in dry condition.</p> <p>2) It is also required to carry sub surface water away from sub layers in heavy rainfall regions</p> <p>3) It helps to reduce occurrence of road defects due to rainwater and rise of groundwater</p> <p>4) It is beneficial to minimize landslides and related undesirable effects.</p> <p>5) It increases load carrying capacity due to dry condition and maintained density of sub layers</p> <p>6) It also results a good durable road with lesser maintenance as well.</p> <p>State the classification of highway maintenance.</p> <p>Classification of highway maintenance:-</p> <p>1) Routine repairs</p> <p>2) Periodic repairs</p> <p>3) Special repairs</p> <p>4) Resurfacing</p> <p>5) Special repairs to monsoon damage</p> <p>6) Repair to bridge and culverts</p>	1M each 1M each (Any two) $\frac{1}{2}$ M (any four)
Q.2	Attempt any THREE of the following	12
a) Ans:-	<p>Define alignment and state the requirement of an ideal road alignment.</p> <p>Alignment: - The position occupied by centerline of a road in plan is called alignment.</p> <p>Requirements of an ideal road alignment:-</p> <p>1) Short: - In between two terminal station the alignment should be as short as possible. It should provide economy in the cost of construction and maintenance.</p> <p>2) Easy: - The alignment should be easy for the operation of vehicles with easy gradients and curves.</p> <p>3) Safe: - The alignment should be safe for traffic operation.</p> <p>4) Economical: - The alignment should be economical in its cost of construction, maintenance & traffic operation.</p> <p>5) Utility: - The alignment should provide maximum utility by connecting important towns and group of villages.</p> <p>6) Natural aspects: - The alignment should pass through regions of natural beauty and scenery to have good natural aspects.</p>	4 M 1M 1M each (any three)
b) Ans:-	<p>State the necessity of providing extra widening on horizontal curves.</p> <p>The necessity of providing extra widening on horizontal curves: -</p> <p>1) When a vehicle travels on horizontal curves, it occupies more width than that it</p>	4 M



		<p>occupies on straight road. This reduces the capacity of the road in respect of accommodating number of vehicles on horizontal curve. To compensate for this effect the width of the road on horizontal curve is increased.</p> <ol style="list-style-type: none">2) This also increases the visibility on the curves.3) On curves, the vehicles occupy a greater width because the rear wheels follow the inner path as compared to the front wheel.4) On curves, drivers have difficulty in steering their vehicle to keep to the center line of the road.5) Drivers have psychological fear to drive close to the edge of the pavements on curves.	1M each (any four)
c) Ans:-	<p>Explain the procedure for determining softening point of bitumen.</p> <p>Procedure for determining softening point of bitumen:-</p> <ol style="list-style-type: none">1) Sample material is heated to a temperature between 75⁰C to 100⁰C above the approximate point until it is completely fluid and is poured in heated rings placed on metal plate.2) To avoid sticking of the bitumen to metal plate, coating is done to this with a solution of glycerin and dextrin.3) After cooling the rings in air for 30 minutes, the excess bitumen is trimmed and rings are placed in the support.4) At this time, the temperature of distilled water is kept at 50⁰C. This temperature is maintained for 15 minute after which the balls are placed in position.5) The temperature of water is raised at a uniform rate of 5⁰C per minute with a controlled bottom plate by sinking of balls. At least two observations are made.6) For material whose softening point is above 80⁰C, glycerin is used in heating medium and the starting temperature is 35⁰C instead of 5⁰C.	4 M 4M	
d) Ans:-	<p>Define PCU and list four factors affecting passenger car unit.</p> <p>Passenger car unit: - In order to convert the different vehicles classes to one class such as passenger car conversion factor, is known as passenger car unit.</p> <p>Factors affecting passenger car unit:-</p> <ol style="list-style-type: none">1) It depends upon the factors like environmental and climatic conditions.2) It depends upon the factors like dimensions, power, speed, acceleration and braking characteristics.3) It depends upon the factors like roadway characteristics which includes road geometrics, rural or urban roads and types of intersections.4) It depends upon the factors like different vehicle classes.5) It depends upon the factors like regulations and control of traffic.	4 M 1M 1M each (any three)	

3		Attempt any THREE of the following :	(12)
	(a) Ans.	<p>Calculate the safe stopping sight distance for a design speed of 50 Kmph for a two way traffic in a single lane road.</p> <p>Assume $f = 0.37$ and reaction time = 2.5 seconds.</p> <p>Given data:</p>	(4 M)

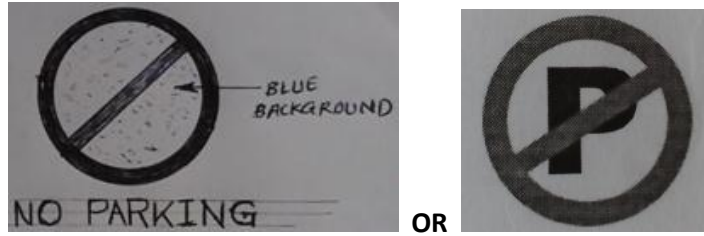


		<p>V = 50 Kmph t = 2.5 seconds f = 0.37 SSD = $0.278 V t + (V^2 / 254 f)$ = $(0.278 \times 50 \times 2.5) + (50^2 / (254 \times 0.37))$ = 34.75 + 26.60 SSD = 61.35 m. for one way traffic. SSD for Two Way traffic on single lane road = 2 x SSD for one way traffic = 2 x 61.35 m = 122.70 m say 123 m.</p>	<p>1 M</p> <p>1 M</p> <p>2 M</p>
3	(b) Ans.	<p>Explain the procedure for flakiness an elongation test on aggregate.</p> <p>Procedure for Flakiness Test:</p> <ol style="list-style-type: none">1) The sample of aggregate to be tested is first sieved through a set of sieves and separated into specified size ranges. Now to separate the flaky material, the aggregates which pass through the appropriate elongated slot of the thickness gauge are found.2) The width of the appropriate slot would be 0.6 of the average of the size range. If the selected size range of aggregate in a group is 20 – 16 mm (i.e., passing 20 mm and retained on 16 mm sieve), the width of the slot to be selected in thickness gauge would be $18 \times 0.6 = 10.8$ mm.3) The flaky material passing the appropriate slot from each size range of aggregate are added up and let this total weight of flaky particles be W1 gm.4) If the total weight of sample taken from the different size ranges is W gm., the flakiness index is given by $(W1/W) \times 100$ percent; in other words Flakiness Index(FI) is the percentage of flaky materials, the widths of which are less than 0.6 of the mean dimensions. <p>Procedure for Elongation Test:</p> <ol style="list-style-type: none">1) The sample of aggregate to be tested is first sieved through a set of sieves and separated into specified size ranges.2) The longest side of aggregate particles from each of the size range is then individually passed through the appropriate gauge of the length gauge; the gauge length would be 1.8 times the mean size of the aggregate.3) The portion of the elongated aggregate having length greater than the specified gauge from each size range is weighed.4) The total weight of the elongated stones is expressed as percentage of the total of the sample taken to obtain the elongation index.	<p>(4 M)</p> <p>2 M (½ M each)</p> <p>2 M (½ M each)</p>
3	(c) Ans.	<p>Discuss the merits and demerits of bitumen road.</p> <p>The merits of bitumen road are as follows:</p> <ol style="list-style-type: none">1) It gives joint less smooth surface.2) Failure of Bitumen road is gradual.3) The quick repair of road is possible.4) Curing time is less.5) It can be opened to traffic soon as compared to concrete road.6) In this road, initial investment is less.7) Overall life cycle cost of bitumen road is less.8) It gives the lower noise level. <p>The demerits of bitumen road are as follows:</p>	<p>(4 M)</p> <p>2 M (any four ½ M each)</p>



		<ol style="list-style-type: none"> 1) Bitumen roads are less durable. 2) They have less tensile strength. 3) They develop hydrocarbon pollution to soil. 4) Maintenance cost is more than cement concrete road. 	<p>2 M (½ M each)</p>
3	<p>(d) Ans.</p>	<p>List any four causes of Accidents. Causes of Road Accidents: The various causes of accidents may be listed as given below:</p> <ol style="list-style-type: none"> 1) Due to Drivers: Excessive speed and rash driving, carelessness, violation of rules and regulation, failure to see or understand the traffic situation, sign or signal, temporary effects due to fatigue, sleep or effect of consuming alcohol. 2) Due to Pedestrians: Violating regulations, carelessness while using the carriageway meant for vehicular traffic. 3) Due to Passengers: Alighting from or getting into moving vehicles. 4) Due to Vehicle defects: Failure of brakes, steering system, or lighting system, tyre burst and any other defect in the vehicles. 5) Due to Road Condition: Slippery or skidding road surface, pot holes, ruts and other damaged conditions of the road surface, temporary obstruction to line of sight (caused by branch of tree or disabled vehicle) resulting in reduction in normal sight distance. 6) Due to Road Design: Defective geometric design like inadequate sight distance at horizontal or vertical curves, improper curve design, inadequate width of shoulders, improper lighting and improper traffic control devices. 7) Due to Traffic Condition: Other vehicles of the traffic stream, such as a vehicle moving ahead getting involved in accident, presence of disabled vehicle on the roadway. 8) Due to Weather: Unfavorable weather conditions like mist, fog, snow, dust, smoke or heavy rainfall which restrict normal visibility and render driving unsafe. 9) Due to Animals: Stray animals on the road. 10) Other causes: Incorrect signs or signals, gate of level crossing not closed when required, ribbon development, badly located advertisement boards or service stations etc. 	<p>(4 M)</p> <p>(any four) 1 M each</p>
4		<p>Attempt any THREE of the following:</p>	<p>(12)</p>
	<p>(a) Ans.</p>	<p>Draw following road signs:</p> <ol style="list-style-type: none"> (i) Speed limit (ii) No parking (iii) Narrow bridge (iv) Hair pin bend left <p>(1) Speed Limit:</p> 	<p>(4 M)</p> <p>1 M</p>

(2) No Parking:



1 M

(3) Narrow Bridge:



1 M

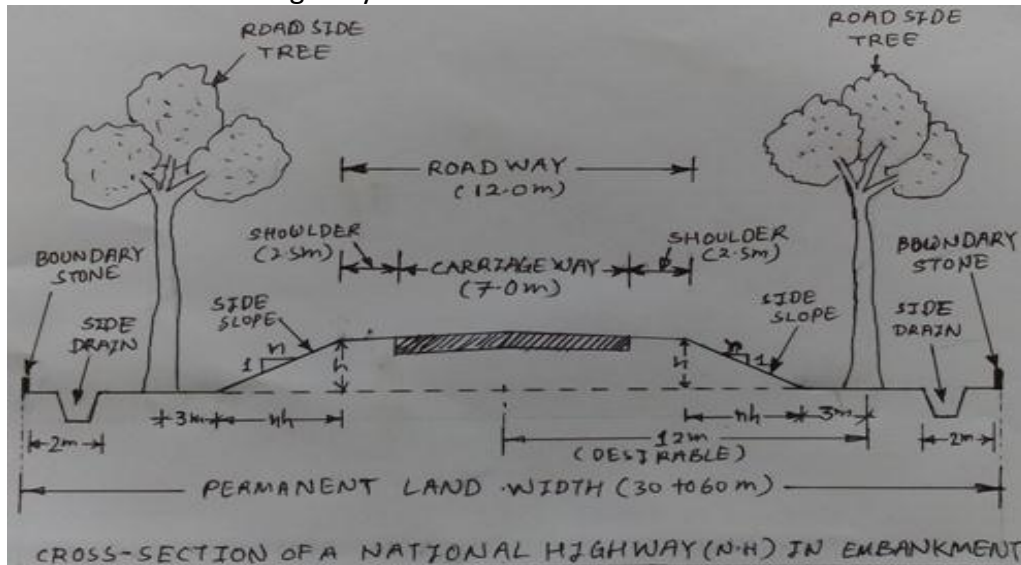
(4) Hair pin bend left:



1 M

4

(b) Draw a neat labeled sketch of National Highway in Embankment.
Ans. Cross-section of National Highway in Embankment:



(4 M)

2 M for figure

1 M for labeling

1 M for dimensions

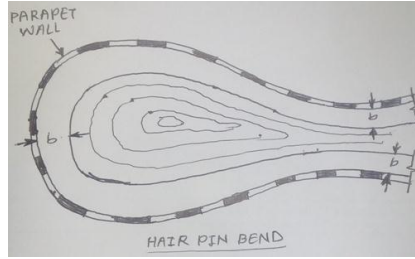
4

(c) Explain the types of hill road curve with neat sketch.
Ans. Types of curves provided on hill road are as follow:

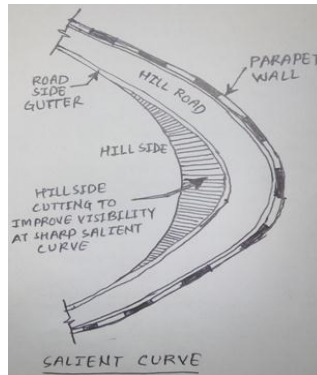
(1) **Hair pin bend curve:** The curve in a hill road which changes its direction through an angle of 180° or so, down the hill on the same side is known as hair pin bend curve. This type of curve should be located on a hill side having the minimum slope and maximum stability. It must also be safe from view point of landslides and ground water. Hair pin bends with long arms and farther spacing are always preferred.

(4 M)

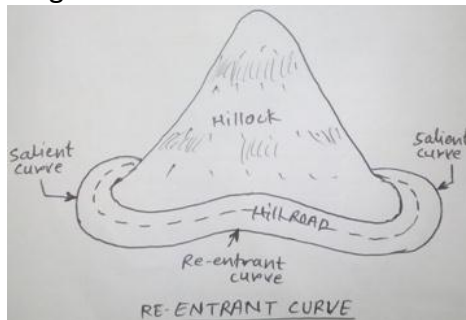
They reduce construction problems and expensive protection works.



(2) Salient curve: The curves having their convexity on the outer edges of a hill road are called salient curves. The centre of curvature of a salient curve lies towards the hill side. This type of curve occurs in the road length constructed on the ridge of a hill. The bend so formed at the salient curve in a hill road is known as corner bend. Salient curves are very dangerous for fast moving traffic. At such a curve or at corner bend, the portion of projecting hill side is usually cut down to improve the visibility.



(3) Re-entrant curve: The curves having their convexity on the inner edge of a hill road are called re-entrant curves. The centre of curvature of a re-entrant curve lies away from the hill side. This type of curve occurs in the road length constructed in the valley of a hill. These curves are less dangerous as they provide adequate visibility to the fast moving traffic. At such curves, the parapet wall is provided only for safety of fast moving traffic.



(any two)
2 M each

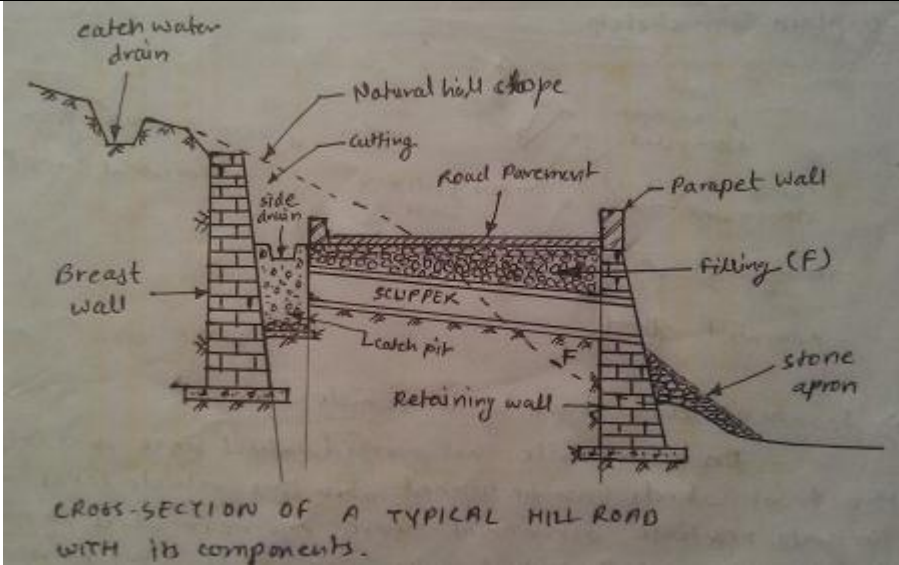
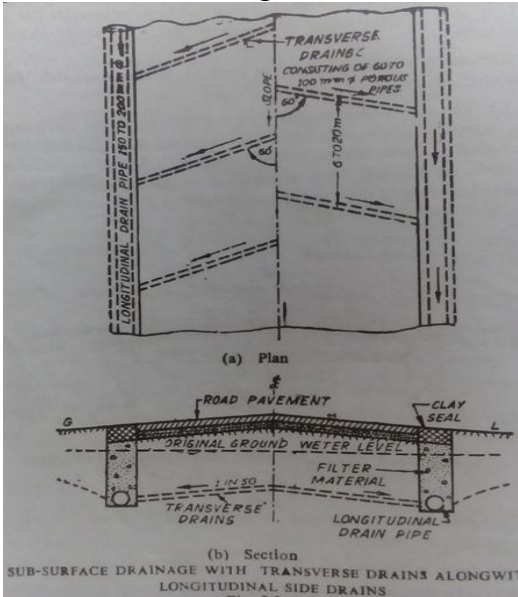
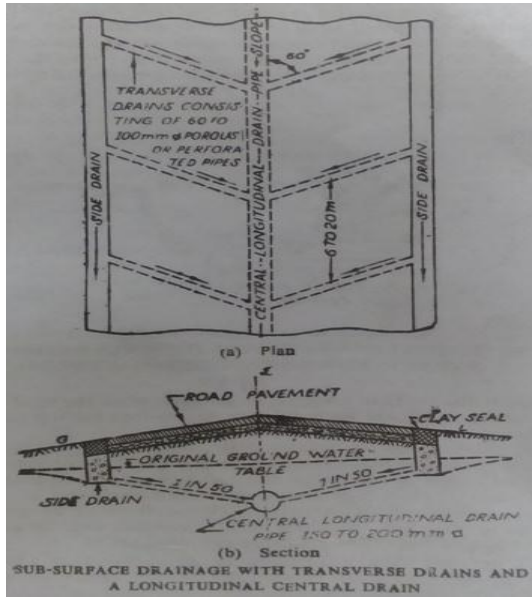
4

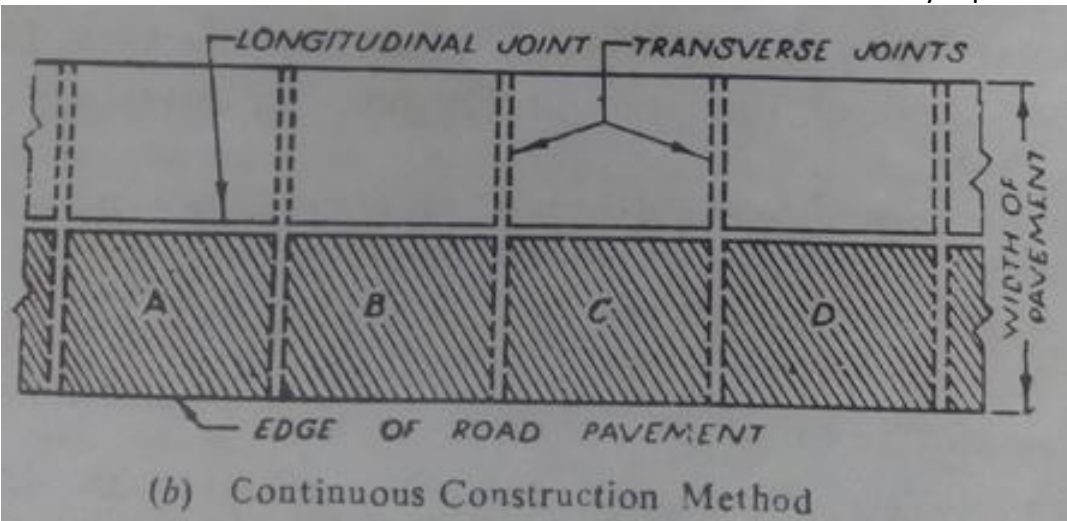
(d)
Ans.

Draw a neat sketch of hill road showing its components.

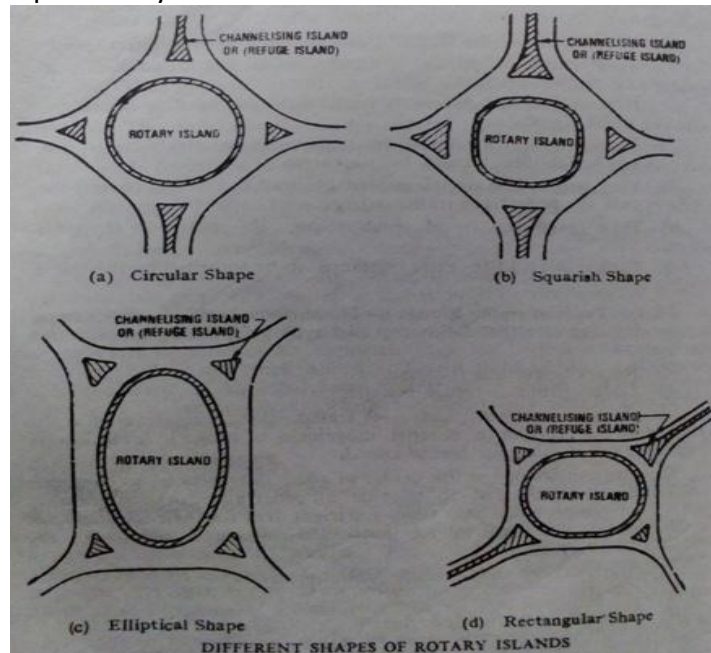
The typical cross section of Hill Road with all component parts is as below:

(4 M)

			<p align="center">4 M (2 M for figure and 2 M for labeling)</p>
<p>4</p>	<p>(e) Ans.</p>	<p>Draw a neat sketch of subsurface drainage. The sub surface drainage is shown as below:</p> <div style="display: flex; justify-content: space-around;"> <div data-bbox="258 787 773 1379">  <p align="center">(a) Plan (b) Section SUB-SURFACE DRAINAGE WITH TRANSVERSE DRAINS ALONG WITH LONGITUDINAL SIDE DRAINS</p> </div> <p align="center">OR</p> <div data-bbox="826 787 1354 1379">  <p align="center">(a) Plan (b) Section SUB-SURFACE DRAINAGE WITH TRANSVERSE DRAINS AND A LONGITUDINAL CENTRAL DRAIN</p> </div> </div>	<p align="center">(4 M)</p> <p align="center">4 M (any one)</p> <p align="center">(2 M for figure and 2 M for labeling)</p>
<p>5</p>		<p>Attempt any TWO of the following:</p>	<p align="center">(12)</p>
	<p>(a) Ans.</p>	<p>Design the rate of super elevation for a Horizontal Highway curve of radius 500 metres and speed 100 Kmph. Assume suitable data.</p> <p>Given data; $V = 100 \text{ Kmph}$ $R = 500 \text{ meter}$ For mixed traffic conditions, Super elevation is given by formula for maximum super elevation: $e = \frac{V^2}{(225 \times R)}$ $= \frac{100^2}{(225 \times 500)}$ $= 0.089 \text{ m per meter of carriage way OR}$ $= 0.089 \times 100$ $= 8.9 \% > 7 \% \text{ (Restricted for Plain terrain)}$ Provide maximum super elevation = $e = 7 \% \text{ i.e. } = 0.07$ </p>	<p align="center">(6 M)</p> <p align="center">1 M</p> <p align="center">1 M</p> <p align="center">1 M</p>

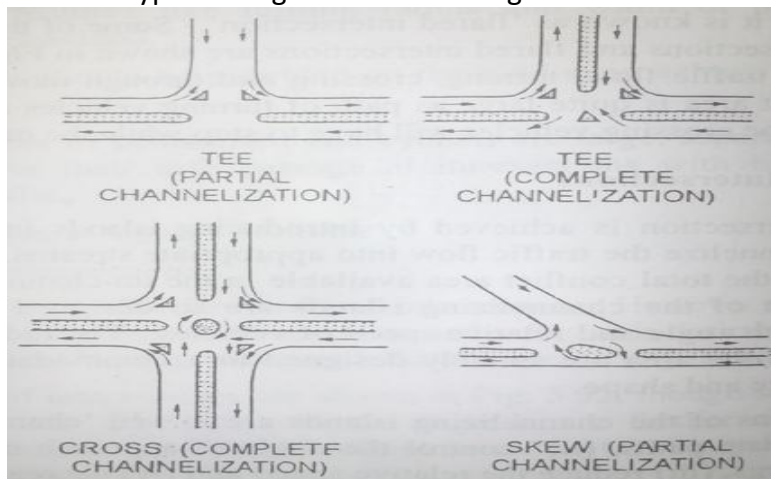
	<p>Now, Check for coefficient of lateral friction developed for full speed using the Primary or Actual equation. $e + f = V^2 / (127 \times R)$ $0.07 + f = 100^2 / (127 \times 500)$ $0.07 + f = 0.157$ $f = 0.157 - 0.07$ $f = 0.087 < 0.15$ (restricted for design purpose) Hence, the design is safe with a super elevation of $e = 0.07$ m per meter length carriage way.</p>	<p style="text-align: right;">1 M</p> <p style="text-align: right;">1 M</p> <p style="text-align: right;">1 M</p>
<p>5</p>	<p>(b) Describe stepwise construction procedure of cement concrete road by continuous bay method.</p> <p>Ans. Continuous Construction method: In this method of construction, all the bays or slabs (ABCD) of strip are constructed continuously without any break as shown in figure. In this method, construction joints are, however, provided when the day's work is not ended at the specified joint. In addition to these, construction joints, dummy joints are also provided at 5 m. intervals in the transverse direction to check the planes of weakness and to control cracking. In this method, expansion joints are constructed at about 16 to 20 m. intervals i.e. after every fourth slab.</p> <p>This method is generally preferred as compared to alternate bay method because of its main advantage of construction of half the pavement width at a time. Thus, the essential traffic can be diverted on the other half of the road. This method is also very rapid.</p> 	<p style="text-align: right;">(6 M)</p> <p style="text-align: right;">4 M</p> <p style="text-align: right;">2 M</p>
<p>5</p>	<p>(c) Enlist different types of traffic island and explain any one in brief with neat sketch.</p> <p>Ans. The different types of traffic island are as follow: (1) Rotary or central islands. (2) Channelising or refuse islands. (1) Rotary or central islands: A traffic island constructed in the centre of an intersection to compel movement of traffic in a clock-wise direction is called rotary or central island. They are constructed at the centre of road intersection to eliminate points of direct conflict and to provide an orderly and organized traffic flow. They are provided only when sufficient area for their construction is available at the road intersection. Their shape depends upon the type of road intersection. Rotary islands are usually of the following shapes: (i) Circular rotary island. (ii) Squarish with rounded edge rotary island.</p>	<p style="text-align: right;">(6 M)</p> <p style="text-align: right;">2 M</p>

- (iii) Elliptical, elongated or oval shaped rotary island.
- (iv) Rectangular shaped rotary island.



(2) Channelising islands: The traffic islands provided at the entries and exist of traffic rotary are called Channelising or refuge islands.

The shape of a Channelising island depends on actual conditions existing at each site of road intersection. A few typical designs of Channelising islands are illustrated below:



4 M for any one type
(2 M for explanation and 2 M for any one figure from it)

6

Attempt any TWO of the following:

(12)

(a)
Ans.

Describe stepwise construction procedure for water bound macadam roads.

The construction procedure of W.B.M. road is discussed below:

- 1. Preparation of subgrade :** The subgrade is prepared to the required grade and camber.
- 2. Preparation of the base course :** After preparing the subgrade or sub base, the required type of base course is constructed with specified materials in conformity with lines, grade and thickness.
- 3. Preparation of intermediate and wearing course:** The preparation of intermediate and wearing course of a WBM road is done in following steps:
 - (i) **Preparing the surface :-** The surface of the newly laid base course on which some traffic has been allowed, is checked and the defective portions are rectified.

(6 M)

1 M



		<p>(ii) <u>Providing edging or earthen kerbs</u> :- After preparing the surface brick-on-end edging is provided along the outer edges of the carriage way of the road.</p> <p>(iii) <u>Spreading of coarse aggregate</u> :- The road metal is spread evenly over the prepared base to the specified thickness.</p> <p>(iv) <u>Dry rolling</u> :- After spreading the coarse aggregate, dry rolling is done by means of a suitable roller. The rolling should be started from edges and gradually shifted towards the centre after properly rolling each strip.</p> <p>(v) <u>Spreading of screenings</u> :- After dry rolling, a blindage layer consisting of stone screenings (12 mm grits) is spread at a slow and uniform rate so as to ensure filling of all voids.</p> <p>(vi) <u>Wet rolling</u> :- After spreading the screenings, the surface is sprinkled over with sufficient quantity of water, swept and rolled.</p> <p>(vii) <u>Application of binding material, watering and rolling</u> :- After the application of screening and wet rolling, the binding material is applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface is freely sprinkled with water and rolled with 6 to 10 tonne roller.</p> <p>(viii) <u>Finishing the surface</u> :- After the final compaction, road surface is allowed to dry overnight.</p> <p>(ix) <u>Setting and drying</u> :- The surface is then allowed to cure for 7 to 9 days.</p> <p>4. Preparation of shoulders : During curing, the shoulders are prepared by filling earth to the specified cross slope. These are then properly compacted by rolling or tamping.</p> <p>5. Open to traffic : After drying, the road is opened to traffic.</p>	<p>4 M</p> <p>1 M</p>
6	(b) Ans.	<p>Discuss the types and causes of landslides with neat sketch.</p> <p>Types of landslides:</p> <p>(1) Fall: It includes free fall and rolling of rocks and debris down the hill slope.</p> <p>(2) Slide: It is the movement of slope forming materials along one or several surfaces down the hill slope. It is caused due to finite shear failure of rocks.</p> <p>(3) Flow: It is the movement of the slope forming materials within the displaced mass. The form taken by the moving materials resembles to that of viscous fluid. In this case, the slip surface cannot be located.</p> <p>(4) Complex land slide: It includes movement due to combined effect of two or more types of landslides.</p> <p>Causes of landslides: The following are the causes of landslide:</p> <ol style="list-style-type: none"> 1) Due to increase in water content during rainy season. 2) Due to Hair-cracking due to alternate swelling and shrinkage of the soil mass. 3) Due to increase in load due to traffic or accumulation of snow on the road surface. 4) Due to removal of part of the mass by excavation and increase in slope angle. 5) Due to undermining caused by erosion. 6) Due to shocks and vibration caused by earthquake and nearby blasting or rocks. 7) Due to formation of faults in bedding planes of the strata due to vibrations. 8) Due to fissuring of pre-consolidated mass due to release of lateral pressure while doing cutting of rocks. 9) Due to seepage pressure of percolating ground water. 10) Due to failure of retaining wall or breast wall. 	<p>(6 M)</p> <p>2 M (½ M each)</p> <p>4 M (any eight points) ½ M each</p>
6	(C)	<p>Discuss the causes of failure in flexible and rigid pavement.</p> <p>Causes of failure in flexible pavement: The following are the causes of failure in flexible</p>	(6 M)

