WINTER – 18 EXAMINATION

Subject Name: Highway Engineering **Model Answer** Subject Code: 22302

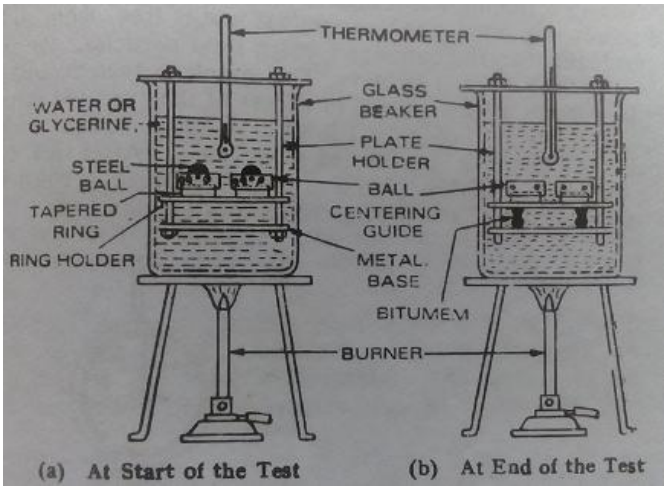
Important Instructions to examiners:

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.

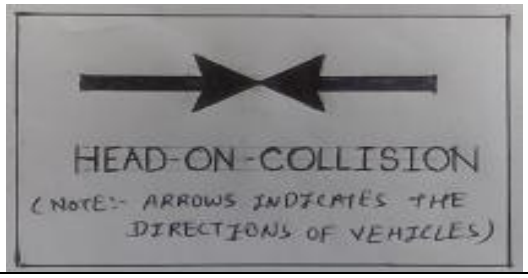
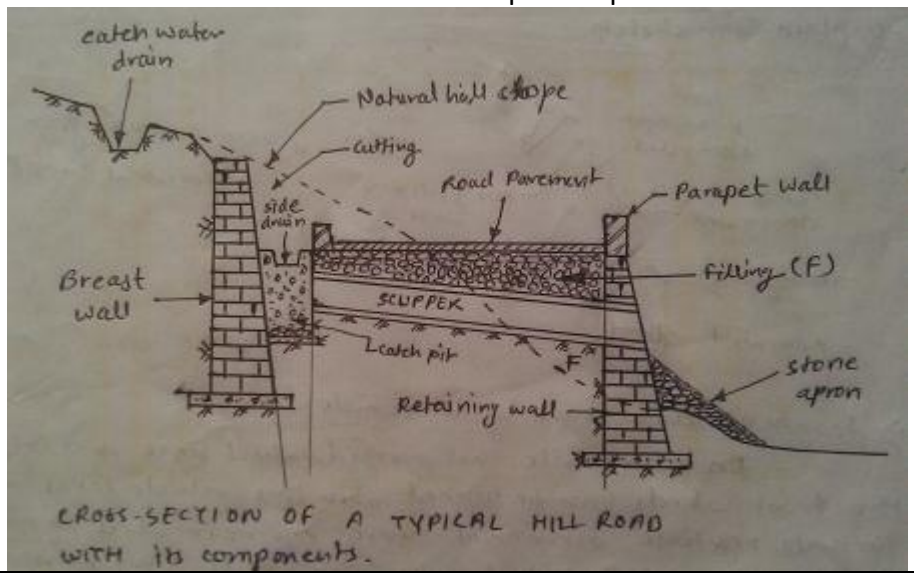
Q. No.	Sub Q. N.	Answer	Marking Scheme
Q.1		***Attempt any FIVE of the following.***	**(10)**
Q.1	a) Ans:-	***State two characteristics of Road Transport.*** **Characteristics of road transport-** 1) Road transport offers complete freedom to road user to transfer the vehicle from one lane to other. 2) 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:-	***Define Kerb and Right of way.*** **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:-	***Define Camber and super-Elevation.*** **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:-	***Define Flakiness Index and Elongation Index.*** **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

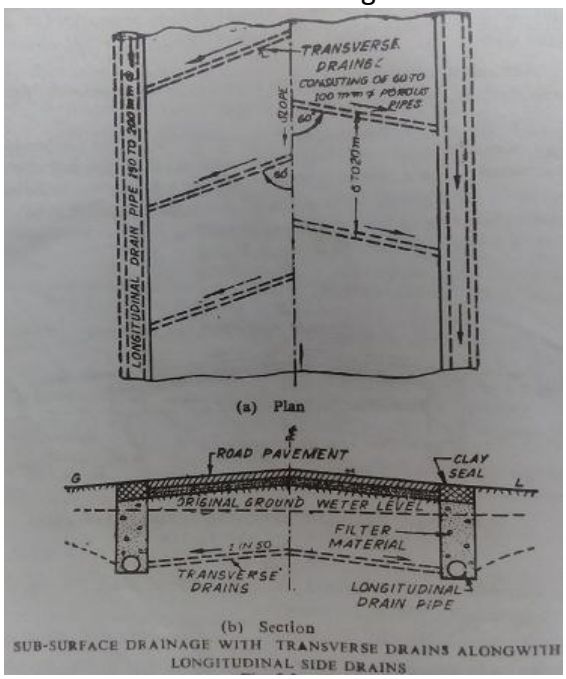
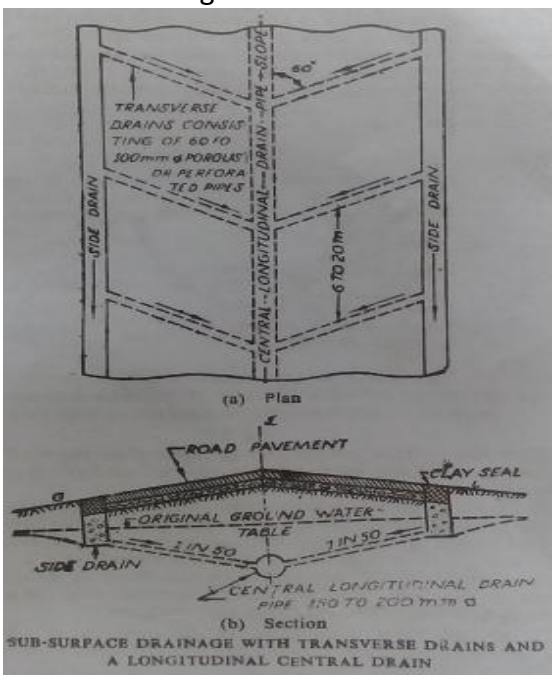
		greatest dimension (length) is greater than one fifth times (1.8) their mean dimension.	
Q.1	e) Ans:-	***List various types of curves provided on Hill Roads.*** Types of curves provided on hill roads: - 1) Hair pin curves 2) Salient curves 3) Re-entrant curves	02 M
Q.1	f) Ans:-	***State the necessity 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)

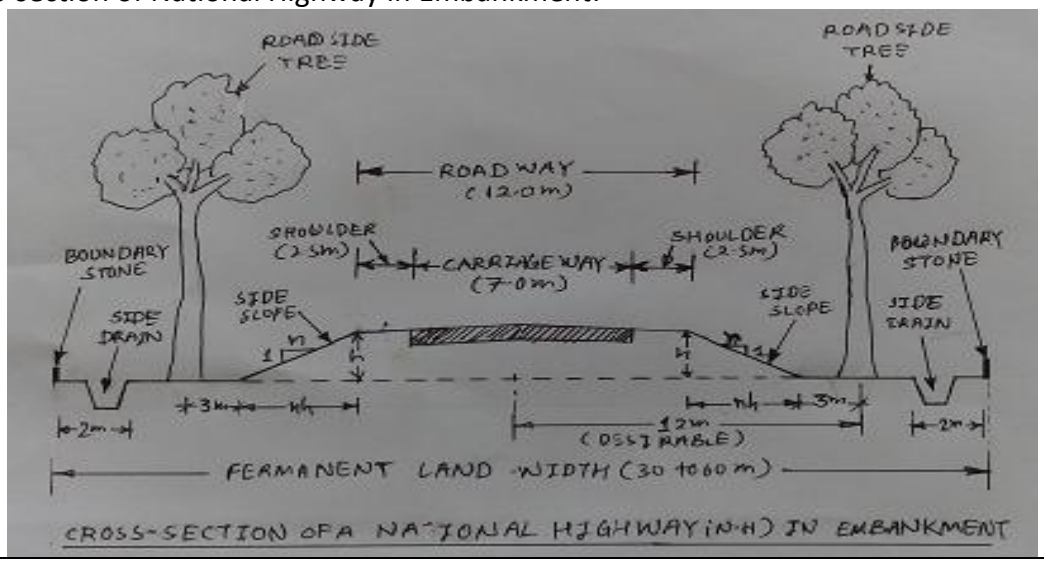
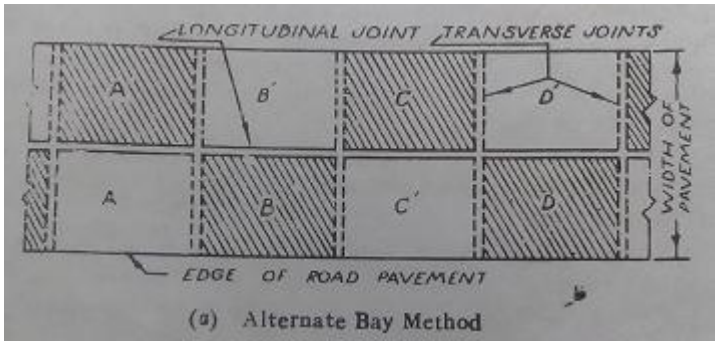
		6) Importance of highway.	
Q.2	c) Ans:-	***Define gradient. Explain types of gradient.(Any Two)*** **Gradient:-**It is the rate of rise or fall of ground with respective to horizontal, is known as *Gradient* **OR** The longitudinal slope provided along the length of road, is known as *Gradient.* **Types of gradient –** **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:-	***State and explain functions of Pavement Components.*** **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)**

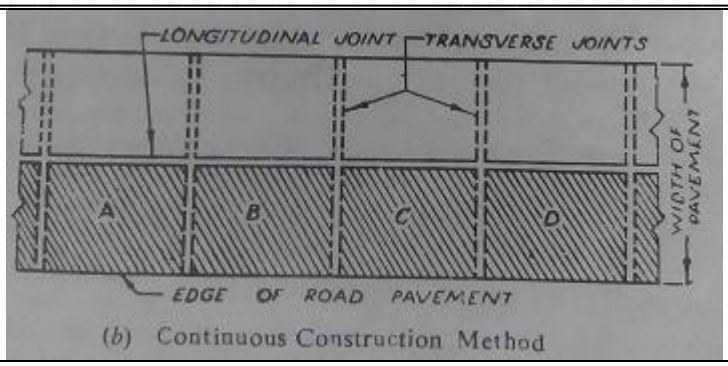
Q.3	(a) Ans.	***Explain the construction procedure of Bituminous Road.*** The construction procedure of bituminous road is summarized as under: **1) Preparation of sub-grade** – The existing ground is made clean to remove dust and other unwanted particles using ordinary and steel brooms. A thin layer 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.	01 M 01 M 01 M 01 M
Q.3	(b) Ans.	***Explain Softening Point Test on Bitumen with neat sketch.*** **Softening Point Test:** The softening point test is conducted by Ring and Ball method in the laboratory as described below:  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^{o} 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.	01 M (for neat sketch) 01 M (for labeling) 02 M

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

		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. **Collision Diagram for Head-on-Collision:**  	02 M
Q.4	(b) Ans.	***Explain preventive measures that can be taken to avoid landslides in hilly area.*** **The preventive measures that can be taken to avoid landslide in hilly area:** 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: 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.	***Draw a typical cross-section of Hill Road and label all component parts.*** The typical cross section of Hill Road with all component parts is as below:  	04 M (02 M for figure and 02 M for labeling)
Q.4	(d) Ans.	***State the functions of surface drainage and sub-surface drainage.*** **Function of Surface drainage:**	

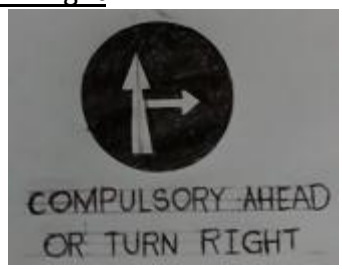
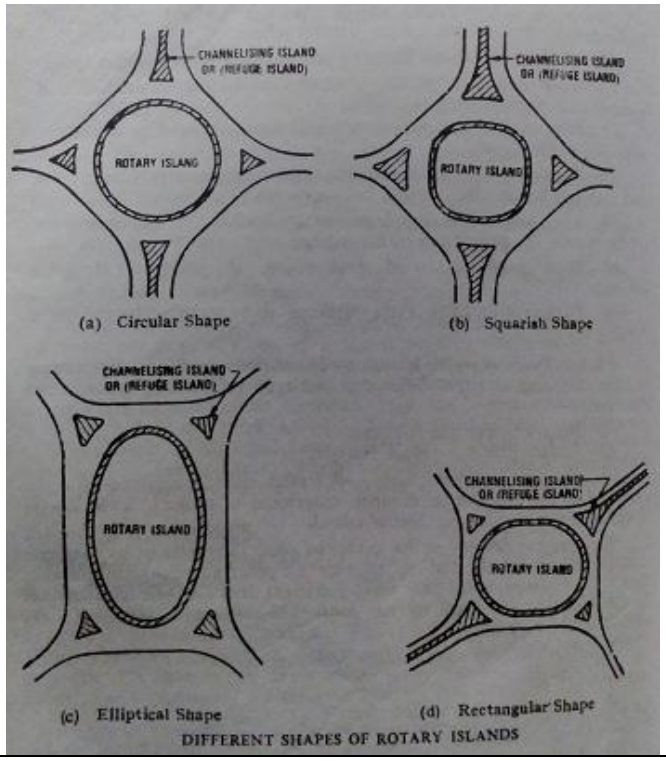
		The function of Surface drainage is to drain the water from the pavement surface and the shoulders during the rains and to divert it to the road-side drains such that the entry of water into the pavement layers and the subgrade soil is minimized. **Function of Sub-surface drainage:** The function of 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) Ans.	***Draw a neat sketch (Plan & Section) of Longitudinal drain and Cross drain.*** The Plan and section of Longitudinal drain and Cross drain is as given below:  SUB-SURFACE DRAINAGE WITH TRANSVERSE DRAINS ALONGWITH LONGITUDINAL SIDE DRAINS **OR**  SUB-SURFACE DRAINAGE WITH TRANSVERSE DRAINS AND A LONGITUDINAL CENTRAL DRAIN	04 M (02 M for figure and 02 M for labeling)
Q.5		***Attempt any TWO of the following:***	**(12)**
Q.5	(a) Ans.	***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%.*** Given data: V = 60 Kmph t = 2.5 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) x 0.6 = **0.3** **SSD = 0.278 V t + (V^2 / 254 f)** = (0.278 x 60 x 2.5) + (60^2 / (254 x 0.3)) = 41.70 + 47.24 **SSD = 88.94 m. for one way traffic.** SSD for Two Way traffic on single lane road = 2 x SSD for one way traffic = 2 x 88.94 m = **177.88 m say 178 m.**	 01 M 01 M 02 M 01 M 01 M

Q.5	(b) Ans.	***Draw a neat cross-section of National Highway in Embankment.*** Cross-section of National Highway in Embankment:  CROSS-SECTION OF A NATIONAL HIGHWAY (N-H) IN EMBANKMENT	02 M for figure 02 M for labeling 02 M for dimensions
Q.5	(c) Ans.	***State the methods of construction of Cement Concrete Road. Explain any one method.*** **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 in more than 4.5 m. This method provides additional working convenience for laying of slabs.  (a) Alternate Bay Method **(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



(b) Continuous Construction Method

Q.6		***Attempt any TWO of the following:***	**(12 M)**
Q.6	(a) Ans.	***Draw Traffic Signs for*** ***(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 –  (ii) No Parking: -  **OR**  (iii) Speed Limit – 60 Kmph:  (iv) Width Limit – 2 m: 	01 M 01 M 01 M 01 M

		(v) Narrow Bridge:  (vi) Compulsory Ahead or Turn Right:  	01 M 01 M
Q.6	(b) Ans.	***Explain Rotary Island (Traffic Island) with a neat sketch*.** **Rotary Island or Traffic Island**: The raised platforms of suitable shapes built on the road intersections are called traffic islands or rotary island. 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. 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.  DIFFERENT SHAPES OF ROTARY ISLANDS	02 M 02 M 02 M for any one figure from (a), (b), (c) or (d)

Q.6	(c)	***Justify the remedial measures for following defects :*** ***(i) Formation of pot holes in case of WBM roads.*** ***(ii) Formation of ruts in case of earthen roads.*** **(iii)** ***Bitumen bleeding in case of bituminous roads.***	
	Ans.	The cross section of hill road is shown below: **(i) <u>Formation of pot holes in case of WBM roads</u> :** The pot holes should be patched up by. (1) Cutting the defective area to rectangular shape and removing the loose stones up to the affected depth. (2) Filling up the prepared area with coarse aggregate of the same size. (3) Watering and compaction by rammer or road roller. (4) Application of wet soil binder to fill up the interstices and compaction. **(ii) <u>Formation of ruts in case of earthen roads</u> :** The remedial measure is quite simple. (1) Cleaning the affected area and light watering. (2) Filling the rut using selected earth. (3) Watering and compaction by rolling. (4) Checking of camber for efficient drainage. **(iii) <u>Bitumen bleeding in case of the bituminous roads</u> :** 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.	02 M 02 M 02 M