WINTER–19 EXAMINATION

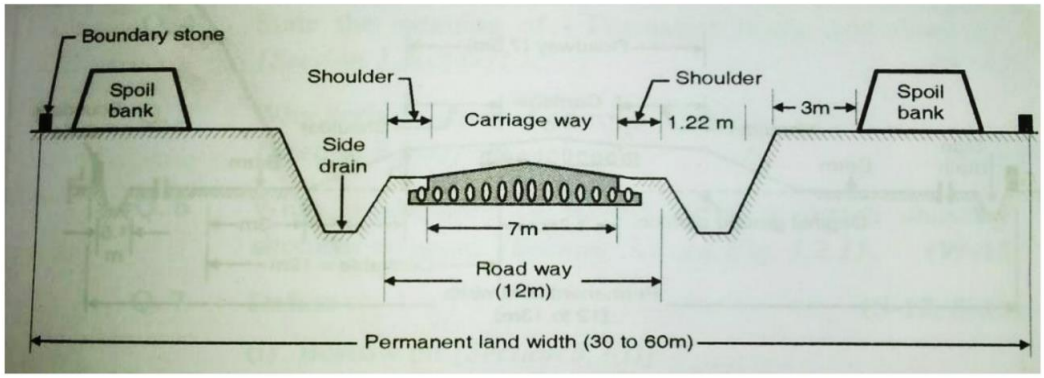
MODEL ANSWER

Subject: Highway Engineering **Subject Code-** **17602**

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.

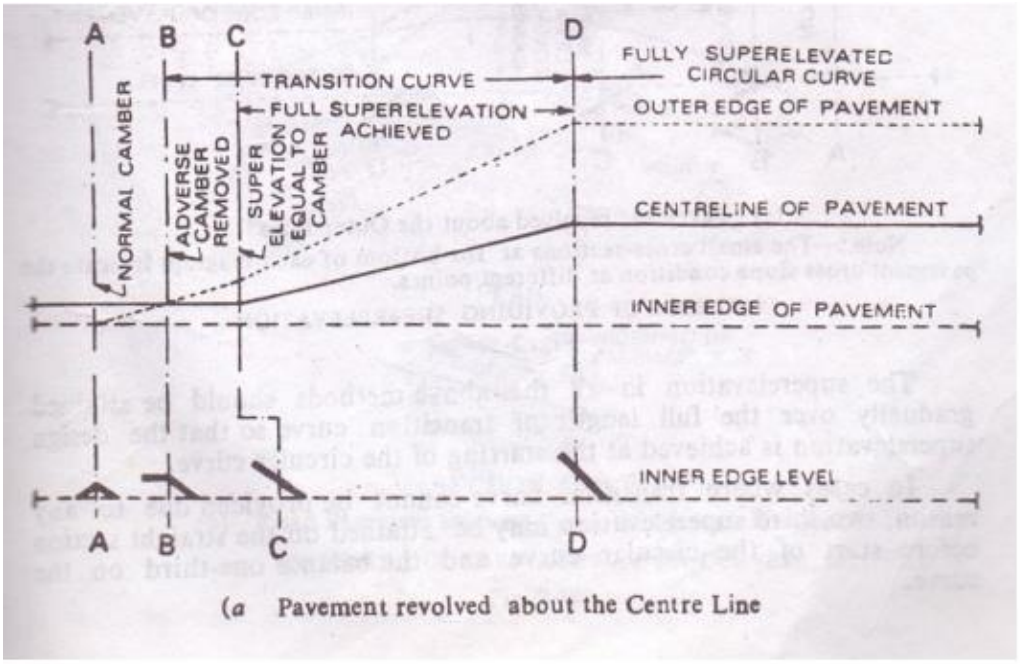
Que. No.	Sub Que.	Model Answer	Marking Scheme	Total Marks
	a)	**Attempt any THREE of the following:**		**12**
1	**i) Ans.**	**State the importance of Road Development Plan**. The road development plan of twenty years is important for the following: a) To increase the kilometerage of major roads and minor roads across the country. b) To bring every village in a developed and semi developed agricultural area. c) To construct and maintain several types of roads to accelerate the pace of economic progress. d) To increase the pavement thickness of existing roads for rapidly increasing vehicles. e) To access traffic problems and execute remedial measures like road diversion, subway, flyover etc. f) To increase social development through connectivity between rural and urban areas. g) To increase industrial development through transportation of goods, fisheries, dairy, products etc	**1 mark each (Any four)**	**4**
	ii) Ans.	**State the characteristics of road transport**. Characteristics of road transport: 1. Road transport gives quick and easy transportation of men, machineries, materials etc. 2. Road transport serves the agricultural area by transporting of goods. 3. It plays a vital role in development of natural resources. 4. The road transportation provides a key in transportation of medical and	**1 mark each (Any four)**	**4**

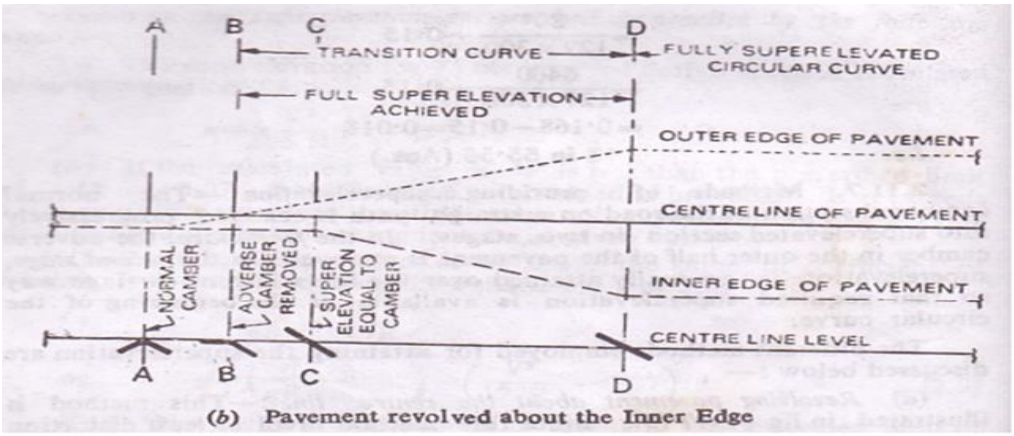
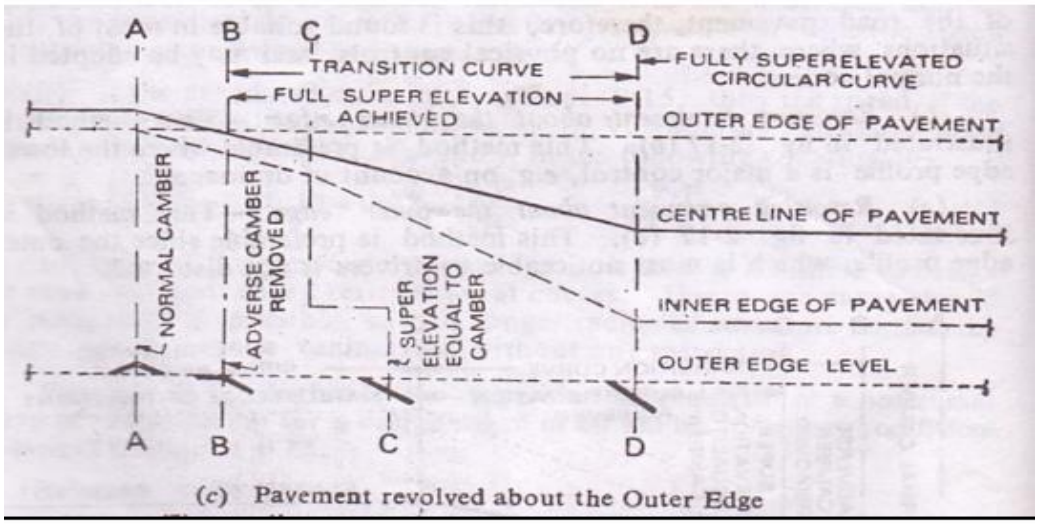
		educational facilities 5. Road transport is a basic need in case of fire and police protections. 6. It gives door step connectivity even in case of rural area or villages. 7. It promotes development of railways, waterways and airways.		
1	**iii) Ans.**	**Define road alignment. State factors affecting road alignment**. **Definition:** The position occupied by center line of a road in plan is called road alignment. Factors affecting alignment of roads: 1. Need of traffic 2. Purpose and class of road 3. Obligatory points 4. Curve 5. Gradient 6. Sight distance 7. Number of CD works 8. Obstruction 9. Earthwork 10. Availability of labour and material	**1** **1 mark each (any three)**	**4**
	iv) Ans.	**Enlist six details to be collected during reconnaissance survey of new highway** a) To collect the details of obstruction along the route which are not available in the map. b) To collect geological features of field. c) To collect information regarding the availability of local construction material, water and labour. d) To determine the approximate values of gradient, length of gradients and radius of curves of alternate alignments. e) To locate the obligatory points along the alternative routes. f) To determine approximate estimate of the total cost of construction of the road along each route. g) To determine two or three best possible routes. **Notes: Credits may be given to any 4 details of the above question.**	**1 mark each**	**4**
1	**v) Ans.**	**Define and state values of following terms with IRC standard for plain areas.** **1) Camber 2) Super-elevation** **1.Camber:** It is the transverse slope provide to the carriage way. OR It is the surface joining crown point to the road edge point. OR It is the slope provided in the transverse direction of the road. **IRC values of camber for different roads in plain area:** 1)Earth road : 3 to 4 % 2)Water Bound Macadam road : 2.5 to 3 % 3)Bituminous road : 2 to 3 % 4)Cement concrete road : up to 2 %	**1** **1**	**4**

		2. Super-elevation: The inward inclination provided to the cross-section of road at sharp curve, so that outer edge is raised with respective inner edge of road, is called as super elevation. **IRC value for plain area -7 %**	**1** **1**	
	b)	**Attempt any ONE of the following:**		**6**
	i) **Ans.**	**Draw a cross-section of N H in cutting and label all its components and give approximate values of the same.**  **(*Note: For neat sketch = 2 marks, labeling =2 marks, and dimensions =2 marks)**		**6**
	ii) **Ans.**	**Design a super-elevation for National Highway with design speed of 70kmph and horizontal curve of radius 210m. Consider coefficient of friction f = 0.15** To design the super elevation, 75 percent of design speed is considered and friction neglected. e = (0.75 * V) ^{2} / (127 x R) or formula can be used as e = V^2 / (225 x R) e = (0.75 * 70) ^{2} / (127 x 210) **e = 0.103 ,** As the value is greater than the maximum super elevation of 0.07, **so actual super elevation to be provided is restricted to 0.07** **check for coefficient of lateral friction** f= (V^2 / (127 x R)) – 0.07 =(70^2 / (127 x 210) - 0.07 =0.113 , it is greater than 0.15 (maximum allowable safe coefficient of friction), **Maximum allowable value of e is 0.07 (7 %).** So as the radius cannot be increased, the speed has to be restricted.	**1** **1** **1** **1** **1** **1**	**6**
2		**Attempt any FOUR of the following:**		**16**
	a) **Ans.**	**Calculate the stopping sight distance for a car moving with design speed 90 kmph. Assume total reaction time of the driver as 2.5 seconds and coefficient of friction as 0.7 and brake efficiency 50%** Design Speed = 90kmph = $90 \times \frac{5}{18}$ **= 25m/s.** **As the brake efficiency 50%, Coefficient of friction (f) = 0.5 x 0.7 = 0.35**	**1**	

		The stopping distance: $$\textbf{SSD}=\frac{V^2}{2gf}+Vt$$ $$\textbf{SSD}=\frac{25^2}{2\times9.81\times0.35}+25\times2.5=91.01+62.50=\textbf{153.51m.}$$ **Hence the SSD for the moving car is 153.51m.** **OR** Design Speed = 90kmph **As the brake efficiency 50%** **Coefficient of friction (f) = 0.5 x 0.7 = 0.35** **The stopping distance:** $$\textbf{SSD}=\frac{V^2}{254f}+0.278\,V\times t$$ $$\textbf{SSD}=\frac{90^2}{254\times0.35}+0.278\times90\times2.5$$ $$=91.11+62.55=\textbf{153.66m}$$ **Hence the SSD for the moving car is 153.66m.**	**1** **2** **OR** **1** **1** **2**	**4**
	b) **Ans.**	**Calculate Overtaking sight-distance for two-way traffic highway with design speed 60 kmph. The rate of acceleration of fast-moving vehicle is 3.6 kmph/sec. and speed of slow-moving vehicle is 4.0 kmph. What will be the overtaking sight distance if only one-way traffic is allowed?** Considering design speed as the speed of the fast-moving vehicle. Hence V = 60kmph. Assume reaction time of the driver **as 2 secs** Vb = 4.0 kmph A = 3.6 kmph/sec $d_1 = 0.278 \times Vb.t = 0.278 \times 4 \times 2 =$ **2.22m.** $d_2 =$ (0.278 × Vb. T + 2s), **s = (0.2Vb +6)** = 0.2 × 4 + 6 = **6.8m.** $T=\sqrt{\frac{14.4s}{A}}=\sqrt{\frac{14.4\times6.8}{3.6}}$ = 5.21secs. Hence, $d_2 = 0.278 \times 4 \times 5.21 + 2 \times 6.8 =$ **19.39m** $d_3 = 0.278 \times VT = 0.278 \times 60 \times 5.21 =$ **86.90m** **hence, for one-way traffic, OSD = $d_1 + d_2$ = 2.22 + 19.39 = 21.61m.** **for two-way traffic, OSD = $d_1 + d_2 + d_3$ = 2.22 + 19.39 + 86.90 = 108.51m.**	**1** **1** **2**	

	c) Ans.	**State the causes of landslides** **Causes of land slide** – The causes of landslides are as follows. 1. Increase in water content of soil during rainy season. 2. Undermining caused by erosion or excavation. 3. Vibrations and shocks caused by blasting or earthquakes. 4. Hair cracking due to alternate swelling and shrinkage of the soil mass. 5. Formation of faults in bedding planes of the strata due to vibrations. 6. Due to seepage pressure of percolating ground water. 7. Due to failure of breast wall constructed for hill roads.	**1 mark each (Any four)**	**4**
2	**d) Ans.**	**Explain the procedure of penetration Macadam for Bituminous Road Construction** 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 are then compacted using vibratory roller of 6-10 ton capacity. Now a thin layer of bitumen as prime coat is spread manually or mechanically **3. Application of surface dressing courses** – The surface dressing includes application of stone chipping and key aggregate, which are bound together using tack coat followed by roller compaction as per design camber on both sides. **4. Laying of wearing course** – 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 gradient of road. The 30 nos. undulations of maximum 12 mm height are allowed in 30 m length of prepared wearing surface.	**4**	**4**
	e) Ans.	**Define:** **(i) lead (ii) lift (iii) borrow pit (iv) spoil bank** **(i) Lead:** The horizontal distance through which the excavated earth is carried and placed for constructing the bank is called lead. **(ii) Lift:** The vertical distance through which the excavated earth is lifted for constructing a bank is called lift. **(iii) Borrow pit:** The pit dug along the alignment of a road for using their material in the construction of road embankment is known as borrow pit. **(iv) Spoil bank:** The bank constructed from surplus excavated earth on the side of cutting parallel to the alignment of the road is known as spoil bank.	**1 mark each**	**4**

3		**Attempt any FOUR of the following:**		**16**
	a)	**Enlist the drawings required for road project.**	**½ mark each. (Any eight)**	**4**
	Ans	**Following are the various drawings required for the road project:** (1) Key map (2) Index Map (3) Preliminary Survey Plan (4) Detailed location survey plan and longitudinal section (5) Detailed cross-section (6) Land acquisition plans (7) Drawing of Road intersections or Road junction (8) Drawing of cross drainage and masonry structures (9) Drawings for retaining walls and other structure (9) Land plans for quarries		
3	**b)**	**Discuss the methods of providing super elevation**		**4**
	Ans	Method of providing super elevation: The different methods employed for attaining the super elevation are as follows: i. Revolving pavement about the centre line. ii. Revolving pavement about the inner edge. iii. Revolving pavement about the outer edge. **(i) Revolving pavement about the centre line :**	**1**	
		 (a Pavement revolved about the Centre Line	**1**	
			1	

3		**ii) Revolving pavement about the inner edge.**  (b) Pavement revolved about the Inner Edge **iii) Revolving pavement about the outer edge.**  (c) Pavement revolved about the Outer Edge	**1**	
	c) Ans.	**Explain the term "Design Speed" and state IRC specification** The maximum speed at which the vehicles can travel continuously and safely under the favorable conditions is known as **design speed.** **As per IRC specifications, Design Speed-**	**2**	

No	**Type of Road**	**Design Speed in km/hr for various terrains**							
		Plain		**Rolling**		**Mountainous**		**Steep**	
		RDS	**MDS**	**RDS**	**MDS**	**RDS**	**MDS**	**RDS**	**MDS**
1	NH & SH	100	80	80	65	50	40	40	30
2	MDR	80	65	65	50	40	30	30	20
3	ODR	65	50	50	40	30	25	25	20
4	VR	50	40	40	35	25	20	25	20

RDS- Ruling Design Speed MDS- Maximum Design Speed.

2 | **4**

3

d) Ans.

Define gradient. Explain types of gradient with IRC recommendation.

Gradient: The rate of rise or fall provided to the formation of a road along its alignment is called "grade" or "gradient". OR

The rate of this rise and fall along the length of road w.r.t. horizontal surface is called as **Gradient.**

1

Types of Gradients: the road gradients are divided in the following **6** categories:

Any 2 (1 mark each)

1) **Average Gradient:** The total rise or fall between any two points on the road divided by the road length is known as the average gradient and it is helpful in carrying put paper or preliminary survey.
2) **Limiting Gradient:** A gradient which must never be exceeded in any part of a road is called the limiting gradient or **maximum gradient**. Sometimes it is referred as **momentum gradient.**
3) **Exceptional Gradient:** Due to some extra ordinary situations and unavoidable circumstances, it sometimes becomes necessary to provide steeper gradient greater then limiting or maximum gradient. Such a gradient is known as exceptional gradient and is provided only for short distances of road not exceeding about 60m.
4) **Floating gradient:** At certain points along the road, there is a combination of rise and fall. Is a vehicle is descending a grade at constant speed and comes across an ascending grade such that it maintains the same speed without any application of the brakes then such a gradient is known as floating gradient.
5) **Minimum Gradient:** It is evident that a road with flat or zero gradient is not efficient for removal of surface water of road. It is therefore necessary to provide a certain minimum gradient to achieve the purpose of easy drainage of road surface and its amount will depend on the nature of ground, rainfall, type of road surface & other site conditions.
6) **Ruling gradient:** The permissible gradient in the alignment of highway is called ruling gradient. This is the gradient for which the road is designed and hence it is known as **Design gradient.**

4

IRC specifications for different Gradients:

No	Type of Terrain	Gradient		
		Ruling	Limiting	Exceptional
1	Plain or Rolling	3.3% (1 in 30)	5% (1 in 20)	6.7% (1 in 15)
2	Mountainous	5% (1 in 20)	6% (1 in 16.7)	7% (1 in 14.3)
3	Steep	6% (1 in 16.7)	7% (1 in 14.3)	8% (1 in 12.5)

1

e) Ans.

State methods of soil stabilization and explain any one.

Methods of soil stabilization are -

i. Mechanical soil stabilization
ii. Soil-lime stabilization
iii. Soil-cement stabilization
iv. Soil-bitumen stabilization

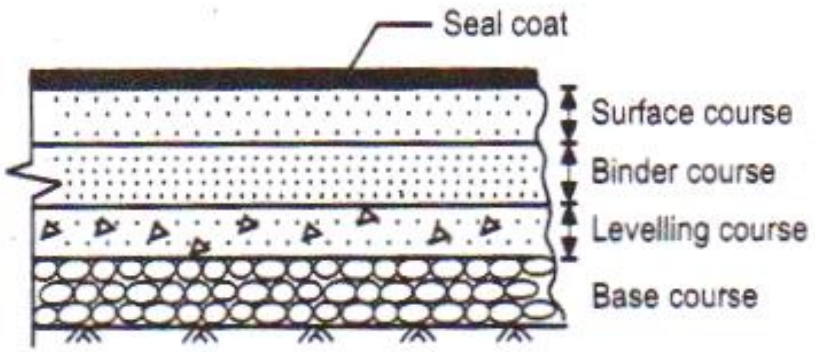
2

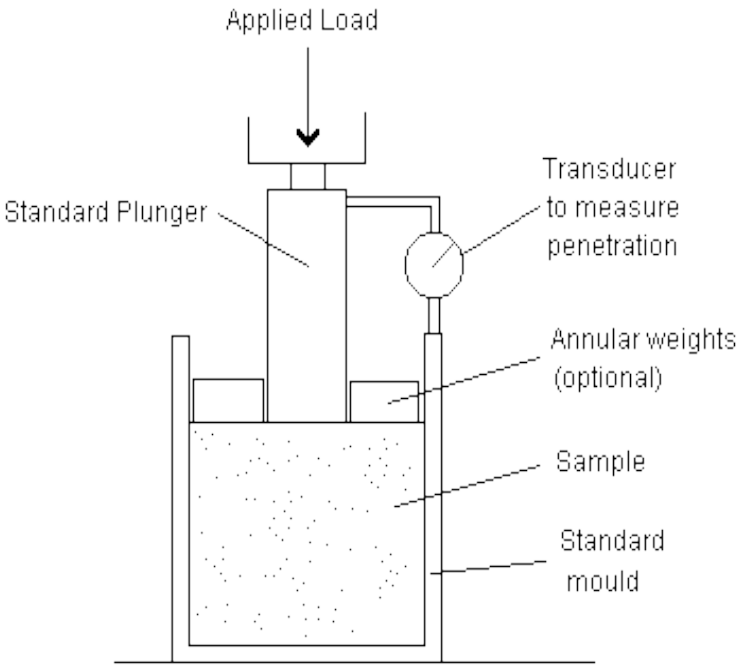
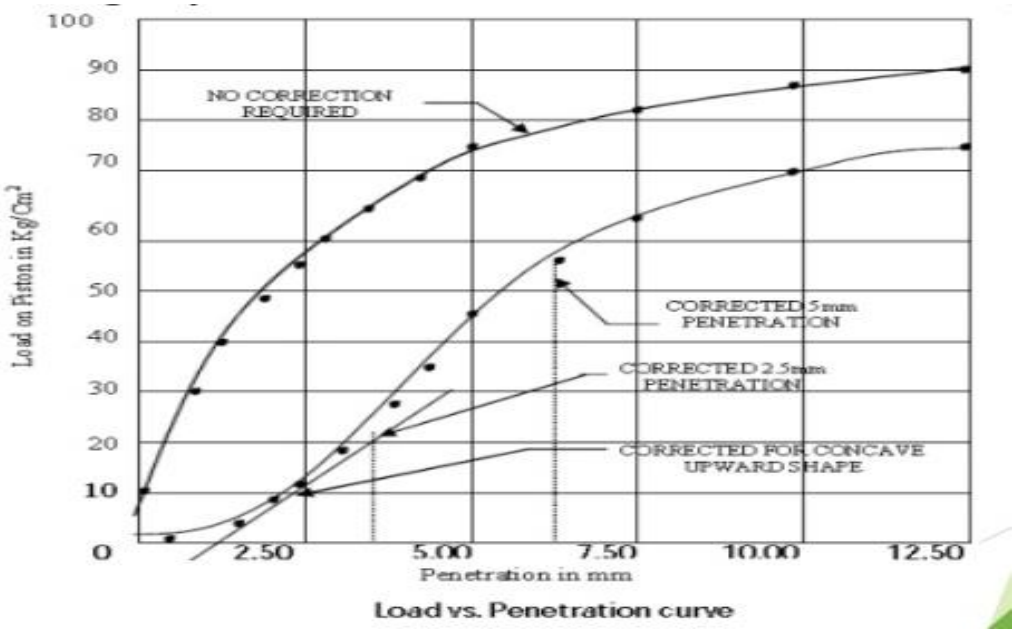
4

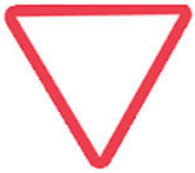
3		v. Fly ash Stabilization vi. Stabilization by heating vii. Stabilization by grouting viii. Stabilization by freezing ix. Stabilization by chemicals i) **Mechanical Stabilization of Soil:** Mechanical Stabilization means stabilization of soil by mechanical means without adding any chemical or admixtures. a) Excavation of subgrade soil should be done by JCB. b) Pulverization should be done to form fine particles. c) A specified size of aggregates as per IRC is added in soil to improve soil particles. The fine particles impart cohesion or binding properties, water retention capacity and acts as a filler for the voids present in the coarse fraction. Then suitable compaction is done using heavy compaction roller followed by curing. d) After alternate curing and compaction for minimum 7 days, the road is said to be stabilized. e) This type of stabilization is used for cheap roads. It is commonly used for the construction of sub-bases, bases and also for improving the sub-grade soils having low bearing capacity. **ii) Soil-Lime stabilization:** The process of lime stabilization of soil is more or less same as cement-soil stabilization except that hydrated lime is used in place of cement. The quantity of lime is about 5 to 10% by weight and the presence of lime helps in reducing shrinkage and swelling of soil. **iii) Soil-cement stabilization:** In this method, the binding property of Portland cement is made use of to stabilize an earth roads and such a road is known as Soil-Cement roads. Procedure: a) The road surface is cleared and the top layer of soil is loosened to a depth required to get the desired thickness of road b) The lumps are then broken and a pulverized material is obtained. If the lumps are hard and the material is fairly dry, the use of smooth roller can also be made c) If any additional soil is required to improve the grading, it should be evenly spread over the loosened roadway material before the starting of mixing operations d) The surface is then covered by a layer of cement and the spreading of cement may be done either by hand or by mechanical spreaders e) The water in required quantity is then sprinkled and the whole mass is intimately mixed by suitable equipment in such a way that uniform colour and texture are obtained The layer is compacted by tamping rollers and the final rolling is done with a self-propelled smooth tandem roller so as to get a smooth surface	**2 marks should be given for any one method and for correct sequence**	

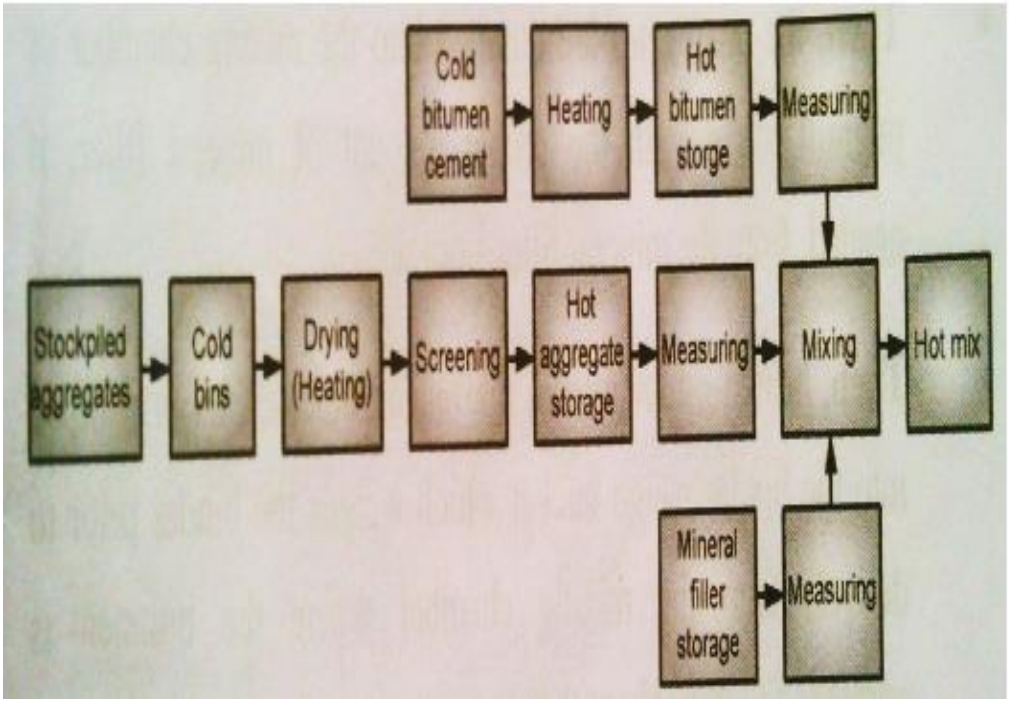
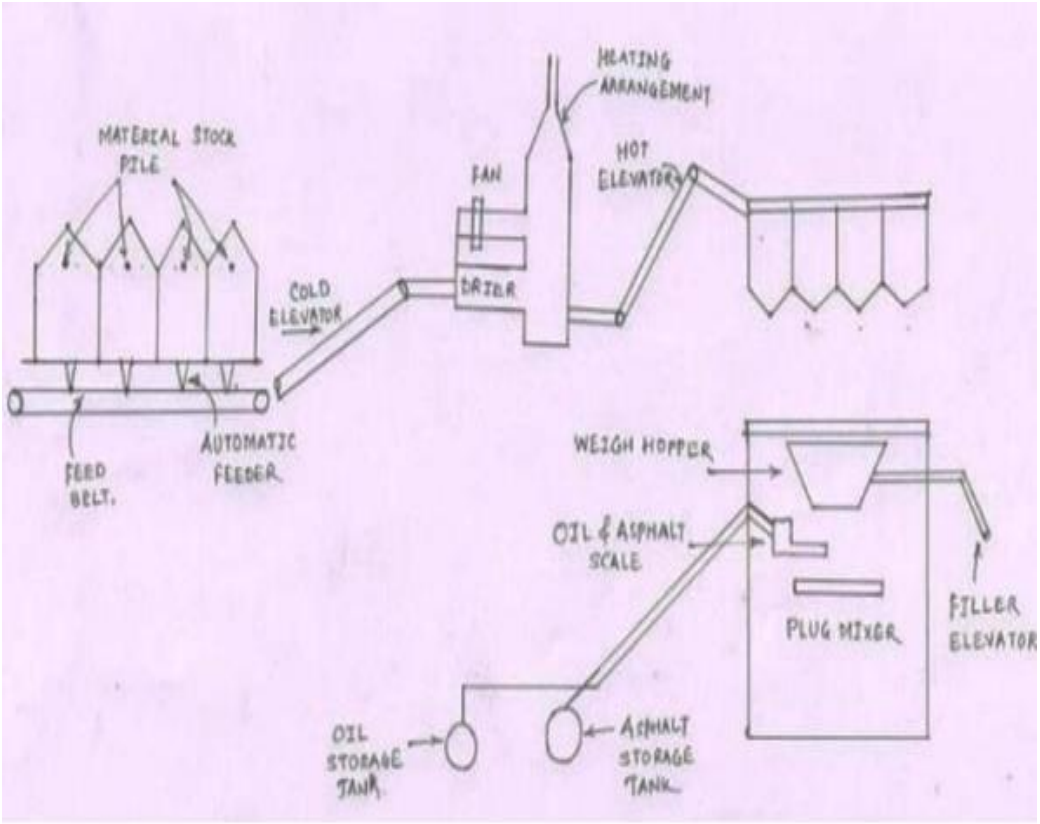
		iv) Bitumen Stabilization: Asphalt and bitumen are the bituminous materials used for the stabilization of soil for pavement construction. Bitumen stabilization takes place in two ways: as a cutback or as emulsion. Bitumen is mixed with water (cutback) and is sprayed on to the soil. The water gets evaporated in 24 hours and the bitumen will bind with soil. Bitumen is mixed with naphtha (emulsion) and is sprayed on the soil. The naphtha gets evaporated in 2-3 hours and the bitumen will bind soil. **v) Fly Ash Stabilization:** Fly ash is an industrial waste obtained from burning of powdered coal. Fly ash reacts with lime only in the presence of water producing a cementitious material. This type of stabilization is successful wherever lime stabilization is effective especially for foundation of residential buildings. **(Note-Any other relevant method should be considered)**		
4	**a)**	**Attempt any THREE of the following:**		**12**
	i) Ans.	**Define pavement. State objectives of pavement.** **Definition:** The term pavement means the surfacing layer only. It is defined as a structure having several layers bound together and placed at the top of the soil subgrade so that it provides a smooth surface for the vehicles. **Objectives:** 1. To carry superimposed moving or dynamic loads of vehicles 2. To distribute the vehicular load in different sub layers without exceeding bearing capacity of subgrade soil 3. To absorb the shocks and vibrations exerted by dynamic loads 4. To dispose off rainwater away from road surface by avoiding entry of water in road substructure. 5. To avoid ground water table rise in if for keeping road in dry condition 6. It provides a smooth surface for the vehicles.	**1** **Any 3 (1 mark each)**	**4**
	ii) Ans.	**Define traffic volume. State the objects of traffic volume study** **Definition:** 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. **Uses/ Objects of Traffic Volume Study:** a) It is used in planning, traffic operation and control of existing facilities and also for planning and design of new facilities b) This is used in analysis of traffic pattern and trends. c) Volume distribution study is used in planning one-way streets and the other regulatory measures d) Pedestrian traffic volume study is used for planning sidewalks, cross walks, subways and pedestrian signals e) To design intersections w.r.t. signal timings, channelization and other	**1** **Any 3**	**4**

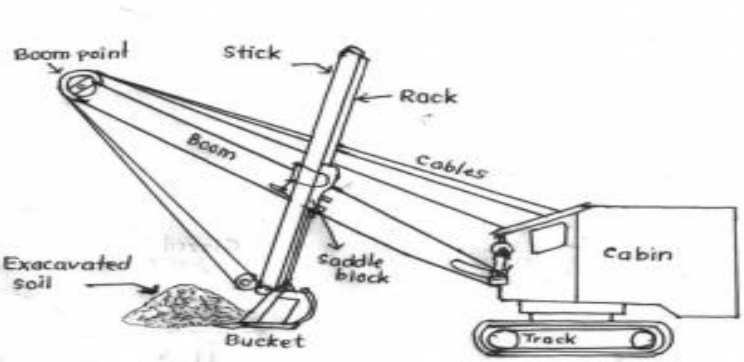
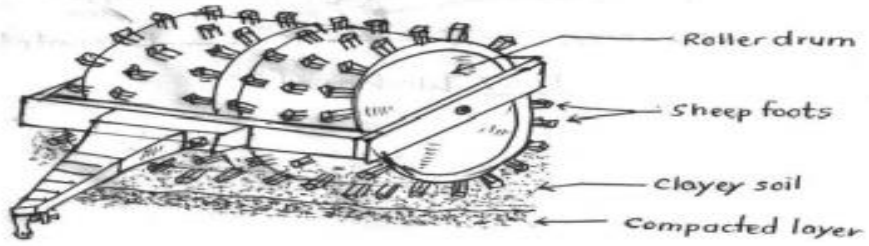
		traffic control devices f) To establish priorities and scheduling of traffic improvements. g) To know the number and weight of heavily loaded vehicles using the road h) To know the number of vehicles going up or down direction on straight roads i) To know the types of vehicles using the road. j) To establish the importance of road. k) To suggest new routes and additional facilities**.**	**(1 mark each)**	
	iii) Ans.	**Define Traffic density and traffic capacity** **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**. **Traffic Capacity:** It is the ability of a roadway to accommodate traffic volume. It is expressed as the maximum number of vehicles in a lane or a road that can pass a given point in unit time usually an hour	**2** **2**	**4**
	iv) Ans.	**State the necessity of drainage in highway** The necessity of highway drainage is: a) It is necessary to collect surface water in side drains and to keep road surface in dry condition. b) To reduce occurrence of road defects due to rainwater and rise of groundwater. c) It also results a good durable road with lesser maintenance as well. d) To travel the collected water by gravity into the nearby natural nallah or stream or river. e) To increase the stability of road pavement. f) To control the moisture content of the road sub-grade. g) To maintain the bearing capacity of the sub-grade soil by preventing the entry of water into it.	**Any 4 (1 mark each)**	**4**
4	**b**	**Attempt any ONE of the following:**		**6**
	i) Ans.	**Describe the procedure of construction of bituminous road and draw a sketch of bituminous road showing its components.** **Construction Procedure of Bituminous Roads:** **a) Preparation of existing surface:** The existing surface is prepared to the proper profile and ruts, depression etc. are rectified before the treatment is done. A prime coat is applied if the existing base course has a previous surface such as soil stabilized material or WBM. **b) Application of binder:** On a prepared surface, using a mechanical sprayer or pouring can, uniform spraying of the bituminous binder is done at the specified rate. Care is taken that excessive binder is not applied to the localised areas as this would cause bleeding. **c) Application of stone chippings:** After the application of binder, the cover material i.e. stone chippings as per the requirement are spread to cover the surface uniformly. d) **Rolling of first or final coat:** The rolling is done with tandem roller of 6 to 8 tonnes weight after the cover material is spread. Rolling is started from the edges proceeding towards the centre longitudinally with overlapping. This is continued until the particles are firmly inter-locked.		

		This is the final rolling if the surface dressing is in single coat. If the second coat is applied then the rolling is done again. e) **Application of the binder and stone chippings for second coat:** The binder is again applied to the prepared surface as per requirements. Immediately after this cover material of smaller aggregates is spread as before. f) **Rolling of second coat:** Soon after the application of materials, the rolling is done as described above. g) **Finishing and opening to traffic:** The surface is checked for longitudinal and cross profile using a straight edge. The road section is opened to traffic after 24 hours.  **Fig. 4.20: Components of a bituminuous road**	**4 marks for correct sequence** **2**	**6**
4	**ii) Ans**	**Explain with neat sketch CBR Test on sub grade material** CBR Test on subgrade soil - 1. Take the soil sample of size 4.75mm to 20mm and add water required for it MDD i.e. Optimum Moisture Content of that soil. 2. Fill this wet soil in inverted CBR mould by compacting each layer with 56 blows of 2.6 Kg hammer. 3. Place CBR mould in regular fashion under CBR Test apparatus with spacer disc at top. And apply seating load with 50mm ϕ plunger. 4. Now apply a constant load at a rate of 1.25 mm/min and observe test loads for each 0.5 mm penetration up to maximum 12.5 mm. 5. Finally, draw a graph of load Vs penetration as shown Fig to note test load at 2.5 mm penetration. 6. Calculate % CBR value as (Test load/Standard load) x 100	**3** **2**	**6**

		  Load vs. Penetration curve	**1**	
5		**Attempt any FOUR of the following:**		**16**
4	**a)**	**Draw following road sign** **i) No parking** **ii) One way** **iii) Give way** **iv) Narrow bridge**		

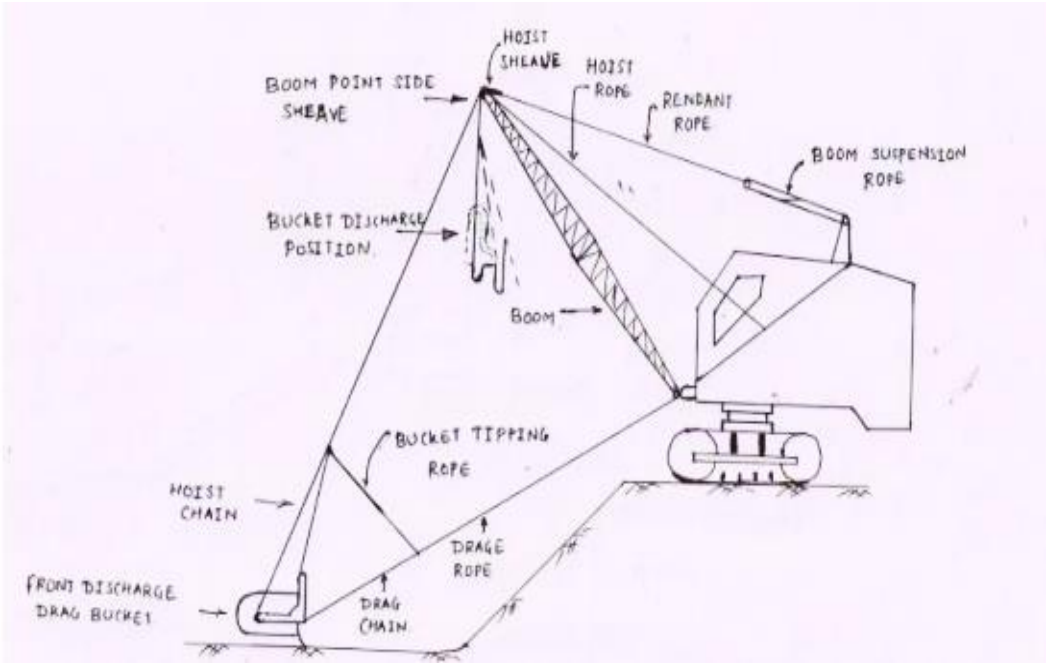
	Ans.	**i) No Parking:**  **or**  **ii) One way:**  **iii) Give way**  **iv) Narrow bridge** 	**1 mark each**	**4**
	b) **Ans.**	**Discuss the special consideration has to be taken while fixing alignment in hill road.** The following are the special considerations to be adopted while deciding alignment of hill road: (i) Length of Road: The alignment of hill road should be as short as possible because cost of road kilometrage in hilly area is comparatively very high. (ii) Geometrical standards of hill roads: The alignment should have proper geometrical standards such as gradient, curves, radius of curves etc. It should be free from sharp hairpin bends. The minimum radius of curve for a hill road allowed is 50 m. for a National or State highway. (iii) Stability: The alignment should be provided along that side of hill which is stable and not very steep. Thus, the alignment of road is to be changed to provide the road on that side of the hill, which is free from landslides. (iv) Cutting through rocks: The alignment should avoid cutting through solid rocks because it is a very costly item. Thus, in order to avoid excessive cutting through rocks, the alignment is to be changed. (v) Existing saddle or pass: The alignment should cross series of hills through the existing saddle or pass. This may tend to make change in the alignment of the road so as to avoid heavy cost of cutting through rocks.	**1 mark each (Any four)**	**4**

5	c) Ans.	**Draw process flow chart of not mix bitumen plant**  **OR**  	**Full marks to be given for all units and correct sequence**	**4**

5	**d) Ans**	**State necessity of maintenance of roads** **Necessity of maintenance of roads -** 1. To avoid various defects occurring in roads i.e. Potholes, cracks etc. 2. To minimize road accidents that can take place due to road defects 3. To help in safe and smooth vehicular movements on road surface 4. To keep road features in good conditions on as per geometric design suggested by IRC 5. To increase ultimate life of road structure 6. To prevent the water from accumulating on the road	**1 mark each (Any four)**	**4**
	e) Ans.	**Name and draw sketch of suitable equipment for the following road construction activity** **i) Excavation up to 1 m depth in soft Murum** **ii) Compaction in soft clay soil**  Fig. 5. Power Shovel for excavation upto 1m to in soft murum  Fig. 6. Sheep foot roller for compaction in soft clay soil	**2** **2**	**4**

	f) Ans.	**Describe in brief joints in concrete road.** Following are the joints in Rigid Pavements a) Longitudinal joints b) Transverse Joints **Longitudinal joints:** The joints provided in the longitudinal direction between two strips of the road slab, when the pavement width exceeds 4.5 m are known as longitudinal joints. Types of Longitudinal joints are a) Plain Butt joint. b) Butt joint with tie bar. c) Tongue and groove warping joint. **Transverse joints:** The joints provided in the Transverse direction between two strips of the road slab, maximum at 5 m intervals are known as transverse joints. Types of Transverse joints are a) Expansion joint. b) Contractions joints. c) Warping joints. d) Construction joints. **Note: If students have written objects of joints and sketches are drawn marks to be given.**	**1** **1** **1** **1**	**4**
6		**Attempt any FOUR of the following**		**16**
	a) Ans.	**State the use of compacting equipment** **The uses of compacting equipment are as follows:** i) for compaction of earth roads, WBM roads ii) for compaction of trenches, slopes, iii)To prepare subgrade of soils for both flexible and rigid pavements. iv) To compact thick layers of road metal in WBM road construction. v) To compress bituminous concentrated layers in roads. vi) To consolidate the stone chippings, soil and sand. vii) To compact concrete slabs in rigid pavements.	**1 mark each (Any four)**	**4**
	b) Ans.	**Enlist eight equipment used for excavation work.** 1. JCB. 2. Power shovels. 3. Draglines. 4. Dredgers. 5. Rippers. 6. Scrapers. 7. Graders 8. Bulldozers	**½ mark each (any eight)**	**4**
	c) Ans.	**Describe in brief drainage structure in hill road** An adequate and effective drainage is very essential for better service and less maintenance cost of hill roads. The drainage of hill roads consists of the following structure:		

		1. Surface Drainage 2. Controlling Seepage flow 3. Cross drainage 1) **Surface Drainage:** In case of hill roads, surface water causes erosion to the road surface and hill sides and may result in landslides or slips. A proper arrangement for drainage of surface water is therefore, importance to prevent erosion and landslides. An efficient network of surface drainage system of a hill road consists of Side drains and Catch water drains or Intercepting drains. 2) **Controlling Seepage flow**: When the general ground as well as the impervious strata lying underneath are slopping, the seepage flow is likely to exist. If the seepage zone is at a depth less than 0.6 to 0.9 m from the surface of pavement, it is desirable to intercept the seepage flow. For controlling seepage flow, sub-surface drains are provided at foot of the hill slope. 3) **Cross drainage**: An efficient cross drainage system is essential for disposing off the surface water collected by catch water drains and side drains across the hill road. It consists in providing cross drainage structure at frequent intervals. An effective cross drainage system prevents side drains from overflowing and flooding the road surface. Cross drainage is provided by constructing Small under drains, Scuppers, Causeways, Culverts and Minor or Major bridges **Note: If students have written the explanation in short and sketches are drawn marks to be given.**	**1** **1** **1** **1**	**4**
6	**d) Ans.**	**State and explain any four defects observed in cement concrete road** The defect in cement concrete road are: a) **Cracks:** The main type of cracks in CC roads are temperature cracks due to temperature stresses & structural cracks due to combined wheel load and usually stresses in the slab. Usually presence of fine cracks is not harmful and do not admit water into the subgrade. Due to application of heavy loads and variations in temperature and moisture conditions, the cracks get widened and water starts percolating in the subgrade. b) **Disintegration of cement concrete**: This happens when the mix used for the pavement is deficient. The presence of some chemical impurities may damage the mix. c) **Mud pumping**: Mud Pumping is recognised when the soil slurry ejects out through the joints and cracks of cement concrete pavement caused during the downward movement of slab under heavy wheel loads. Following are the factors that cause Mud Pumping: a) Extent of slab deflection b) Type of subgrade soil c) Amount of free water. d) **Warping cracks:** It is the bending of the slab due to uneven expansion or contraction of the top and bottom slab surface. This is caused by the difference in temperature above and below the slab or difference in moisture condition between the surfaces. e) **Corner Cracking:** The corners of the slab near the junction of transverse and longitudinal joints or the edges of the slab	**1 mark each (Any four)**	**4**

		f) Buckling blow up: The upward buckling of the slab takes place because of excessive expansion of the slab with insufficient joints. **g) Spalling of joints:** It is disintegration of edges directly over the steel resulting in the removal of sound concrete.		
	e) Ans.	**Explain working of a Dragline with neat sketch**  **Working:** The main operation of a dragline is to drag the bucket against the material to be dug. In this machine, digging tool bucket is loosely attached to the boom through cables. It has a long crane boom. The dragline is used for (i) Road excavation (ii) Deep down pipe driving (iii) Surface mining (iv) Construction of ports, harbor (v) Deep down excavation	**2 M for Sketch & 2 M for Working**	**4**