TED (15) 6014
(Revision - 2015)

A20 – 02121

Reg. No……………………
Signature ………………….

DIPLOMA EXAMINATION IN ENGINEERING/TECHNOLOGY/ MANAGEMENT/COMMERCIAL PRACTICE, APRIL – 2020

TRANSPORTATION ENGINEERING

[Maximum Marks: 75] [Time: 2.15 Hours]

PART-A

(Answer ***any three*** questions in one or two sentences. Each question carries 2 marks)

I. 1. State the three E's in Traffic Management.

2. Define Reconnaissance survey.

3. State any two reasons for providing widening of pavement on horizontal curves.

4. Define Pandrol Clips.

5. Define the term terminal building. (3 x 2 = 6)

PART-B

(Answer any ***four*** of the following questions. Each question carries ***6*** marks)

II 1. Explain the functions of Subgrade and Base course in road structure.

2. Explain the necessity of conning of wheels.

3. State the objectives of signaling in railways.

4. Describe the advantages for tunneling.

5. Explain different types of traffic surveys required for planning of road.

6. Describe the needs and types of camber.

7. Explain the method of sinking well foundation for bridges. (4 x 6 = 24)

PART-C

(Answer ***any of the three units*** from the following. Each full question carries 15 marks)

UNIT – I

III (a) Explain the factors affecting highway alignment. (8)

(b) Classify highways based on Nagpur Road Plan, provide brief explanation. (7)

OR

IV (a) Classify and explain the different types of traffic signs used as traffic control devices, Stating their shape and importance. (7)

(b) Calculate the minimum sight distance required to avoid head on collision of two cars approaching from opposite directions at 80kmph and 50kmph. Assume a reaction time of 2.5 seconds, coefficient of friction of 0.7 and a brake efficiency of 50%, (for both cars).(8)

UNIT – II

V (a) Explain the IRC classification of highway gradients. (8)

(b) Draw a labelled diagram of the cross section of road in embankment, showing the cross sectional elements. (7)

OR

VI (a) Explain the application of tack coat, seal coat and prime coat. (7)

(b) Differentiate between Flexible Pavement and Rigid Pavement. (8)

UNIT- III

VII (a) State the advantages and disadvantages of Bull Headed rail and Flat footed rails. (6)

(b) Draw a labelled diagram of typical cross section of broad gauge double line in cutting. (9)

OR

VIII (a) Explain the functions of sleepers. (7)

(b) Classify railway yards based on their function and provide brief explanation. (8)

UNIT - IV

IX (a) List the classification of bridges, stating the reasons for the classification. (8)

(b) Describe the ideal characteristics of bridge site. (7)

OR

X (a) Explain the factors affecting airport site selection. (8)

(b) Classify and explain different types of harbours. (7)

SCHEME OF VALUATION

Scoring Indicators

Revision: 2015 Course Title: TRANSPORTATION ENGINEERING		Course Code: 6014		
Question No.	Scoring Indicator	Split Up Score	Subtotal	Total
I.) 1.	The three E's in traffic management are Education, Enforcement and engineering.	2	2	
I) .2.	• Reconnaissance survey is a rapid and rough survey. • Physical characteristics of area is conducted using simple tools, and proposed route is examined.	1 1	2	
I.) 3.	• Vehicle occupies more width on curves as the rear wheel does not follow the path as front wheels • Drivers tend to keep away from the edge of the road while driving through curves. • Clearance required for vehicles passing simultaneously is greater on curves • To increase visibility of the driver on curves (Each point is 1 mark, student has to give any two points to get 2 marks)		2	

I) 4.	Pandrol Clips are a type of elastic fasteners used for fixing rails to the base plate and on to the sleepers. They are easy to place and are durable.	2	2	
I) 5.	Terminal building is the space provided in an airport for airline operators, facilities for convenience of passengers, office for airport management and other non-aeronautical functions. Or Building where passengers transfer from ground transportation and facilities that allow them to board a plane, with facilities for purchase of ticket, luggage transfer and comfort stations.	2	2	10
II.) 1.	Sub grade is a layer of natural soil prepared by compacting top 50cm of soil at optimum moisture content and maximum dry density to receive layers of pavement materials above it. Loads on the pavement is ultimately received by soil subgrade to disperse it to earth mass. Soil Subgrade should not be overstressed, as excess stress will result in deformation of the layer and ultimately lead to failure of the pavement. Base and Sub-base courses are made of broken stones, bound or unbounded aggregates. Sub base is made of inferior materials than of base course. It is the layer immediately beneath the pavement wearing course. Base and sub-base courses are used primarily to improve the load supporting capacity by distributing the load through a finite thickness.	3 3	6	
II) 2.	Coning of wheels is sloping wheels from the vertical axis. Flanges of wheel are never made flat, but they are in the shape of a cone with a slope of 1 in 20. Coning of wheels is mainly done to maintain the vehicle in central position with respect to the track.	3	6	

	On level track as soon as axle moves towards one rail, the diameter of wheel tread over the rail increases, while it decreases over the other rail. This prevents further movement and axle get back to original position. Coning of wheel reduces wear and tear of wheel flanges and rails and prevents slipping of wheel.	3		
II) 3.	1) To provide safety to passenger, staff, goods, and the rolling stock by preventing a running train from coming in contact with another moving or stationary train. 2) To provide safe distance between trains running on the same track in the same direction. Thus to make maximum use of track. 3) To make the shunting operations safe and efficient. 4) To provide directional indication at diverging junctions. 5) To restrict the speed of train during repairs of track. 6) In marshalling and loco yards to provide safety to shunting operation.	1 1 1 1 1 1	6	
II) 4.	Advantages of tunnelling are: • Due to reduction of the distance overall cost will be less, even if the initial cost is high. • Easier gradients can be provided, thus reducing fuel consumption in hauling over steeper gradients • Reduction in maintenance cost due to less and wear and tear. • In congested cities with little space for construction, tunnels provide movement of traffic convenient with high speed. • Tunnels protect pavement from weathering action of rain, snow and other natural influences. • Protect cities and other conveyance vehicles, passages inside them from destruction during war bombings.	1 1 1 1 1	6	
II) 5.	Different Traffic Surveys required for planning of road are:	1	6	

		• Traffic Volume Study: Traffic volume is the number of vehicles crossing a section of road per unit time at any selected period. Traffic volume study helps in planning, road design, regulation and control. • Speed studies: Speed studies are classified into Spot speed studies and Speed and delay study. Spot Speed study – spot speed is instantaneous speed of a vehicle at a specified section. Delay studies – Study of delay or time lost by traffic during the travel period. • Origin and Destination Studies: Important in planning new highway facilities. The number of vehicular traffic origin and destinations are recorded along with purpose and number of travellers in each trip. • Traffic flow characteristics: Traffic flow of diverging, converging and crossing traffic is studied. Conflicting traffic is identified and corresponding traffic control are designed. • Traffic Capacity: Traffic capacity is the ability of road to accommodate traffic volume. Traffic capacity studies helps in planning road geometrics including the lane width and other road facilities. • Accident Studies: Accident studies are conducted to identify the locations prone to accident. Several data are collected such as, type of vehicle loading details and their registration numbers, cost of accidents and nature of road and traffic conditions at site of accident.	1 1 1 1 1		
6.	II)	Camber or cross slope is the convexity provided to section of a straight road. It is expressed in percentage or 1 Vertical: N horizontal. Need for providing camber are: - To drain surface water. - To separate traffic in two directions. - To improve appearance of road. Based on shape Camber is broadly classified as:	3		

	- Parabolic: Provided so that profile is flat in the middle and steeper towards the edges and is preferred for fast moving vehicles. - Straight line camber – When very flat cross slope is provided as in the case of cement concrete pavements straight line cambers are provided. - Combined (Straight line and parabolic) – In straight camber the contact of the wheel will be uneven, to reduce this combined type cambers are provided.	3	6	
II) 7.	Method of sinking well foundations: - For shallow water depth at site, ring form earthen coffer dam is constructed enclosing the area where foundation is laid. For greater water depth, sheet piling or caissons are used for enclosing the area. After enclosing the area water is pumped out. - When all water is pumped out, curb of RCC is laid on the bed and excavation is carried out inside the curb. - When it reaches about 1m depth, steining of brick masonry, stone masonry, concrete block or cement concrete is laid over curb upto about 1m above the bed level. - Again excavation is done and some weights are kept on steining for sinking it. This process is repeated until steining reaches required depth. During this process if water enters in foundation, it is pumped out. - When steining reaches required depth, bottom is dredged to uniform level and all materials are cleared under the cutting edge of the curb. After it a thick layer of concrete is laid and bottom is sealed (known as plugging). - Water from inside is pumped out and inside of the well is filled with sand. Then a concrete layer is laid on it upto the level of the masonry-work of steining. A concrete cap is placed over the wells.	1 1 1 1 1 1	6	
III) a.	Factors affecting highway alignment are:			

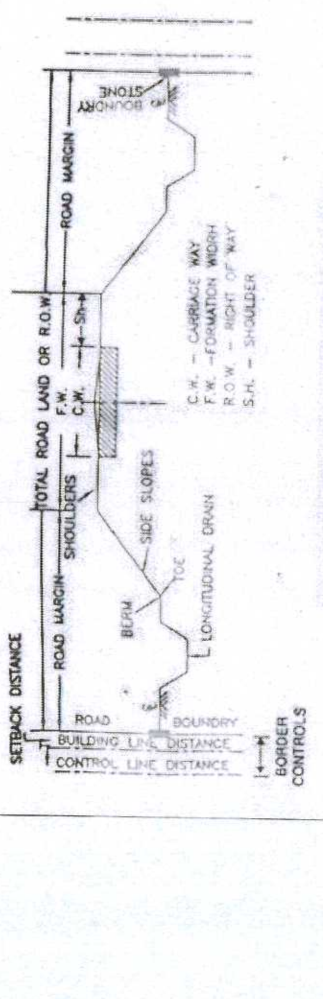
	• Alignment should be as short as possible and as straight as possible between two points. • Should connect maximum number of prominent points. • Alignment should be such that gradients and curves should be smooth. • Number of bridges and culverts should be minimum. • Place of crossing a river must be suitable for a bridge alignment. • Alignment should at most places be at high grounds to ensure good natural drainage of water. • It should avoid locations such as marshy areas, religious places, monuments of historical importance. • It should not be along locations of long stretches of gardens, farm lands and built up areas to avoid high acquisition costs. • Earthwork should be minimum and cutting and filling must be made equivalent to reduce hauling costs. • It should avoid areas through forest land and other habitations. • Materials for construction should be readily and locally available. • Traffic in the area, economy of the reach through which highway passes, foreign territory must be assessed and weighed in while fixing alignment. • Alignment should satisfy the geometric design of the highway, and should provide maximum comfort to the road user. • Alignment should pass through areas of scenic beauty and should avoid monotony. (Any of the above 8 points)		8	
III. b)	**As per Nagpur plan the roads are classified as:** (a) National Highways (b) State Highways (c) Major District Roads (d) Other District Roads (e) Village Roads	2		

	• **National Highways(NH):** National highways are the major roads spanning in the length and breadth of the country. They connect state capitals, Ports and foreign Highways. They are financed by the central Government. They also connect the famous tourism places of the country. National highways are numbered and written as NH-1, NH-2 etc. They have the highest design specifications. • **State Highways(SH):** These are important roads of a state. State highways are the roads which connect important cities and district headquarters in the state, National highways and state highways of neighbouring states. They are financed by state government, State Public Works Department constructs and maintains these roads . They have design specifications similar to those of the National Highways because they carry enough traffic. **District roads:** These are roads within a district and are financed by Zillaparishad with the help of grants provided by State Government. • **Major District Roads(MDR):** These roads connect the district headquarters to the main town centers in the district, and to the headquarters of the other districts also. They also connect these major town centers to the other state highways of importance, production and market centres, with each other and with State and National highways and railway stations.. They have lower design specifications as compared to the NH and SH. • **Other district roads(ODR):** These roads connect the rural areas town centers to the major district roads of higher importance. They provide the facilities for the transportation of the raw materials or the goods mainly of agricultural products from the rural towns to the higher markets and vice-versa. These are district roads of lesser importance. • **Village Roads(VR):** These roads connect the rural villages with one another and to the nearest higher level road or to the nearest town center. They have lower design specifications and many of them are not even metaled. They are also financed by Zillaparishads with the help of funds provided by the State Government.	1 1 1 1 1	7		**15**

IV) a.	There are traffic signs covering wide variety of traffic situations. They can be classified into three main categories. 1. Regulatory signs 2. Warning signs 3. Informative signs **1) Regulatory signs** These signs are also called mandatory signs because it is mandatory that the drivers must obey these signs. If the driver fails to obey them, the control agency has the right to take legal action against the driver. These signs are primarily meant for the safety of other road users. These signs have generally black legend on a white background. They are circular in shape with red borders. The regulatory signs can be further classified into : 1. Right of way series: These include two unique signs that assign the right of way to the selected approaches of an intersection. They are the STOP sign and GIVE WAY sign 2. Speed series. 3. Movement series: 4. Parking series: 5. Pedestrian series: **Warning signs:** Warning signs or cautionary signs give information to the driver about the impending road condition. They advise the driver to obey the rules. These signs are meant for the own safety of drivers. They call for extra vigilance from the part of drivers. The colour convention used for this type of signs is that the legend will be black in colour with a white background. The shape used is upward triangular or diamond shape with red borders. Examples of cautionary signs are right hand curve sign board, signs for narrow road, sign indicating railway track ahead.	1 2 2	7	15

	Informative signs: Informative signs also called guide signs, are provided to assist the drivers to reach their desired destinations. These are predominantly meant for the drivers who are unfamiliar to the place. Some of the examples for these type of signs are route markers, destination signs, mile posts, service information, recreational and cultural interest area signing etc. Route markers are used to identify numbered highways. They are written black letters on yellow background. Destination signs are used to indicate the direction to the critical destination points, and to mark important intersections. They are colour coded as white letters with green background.	2		
IV) b.	**Given:** Speed of first car ,V_1= 80kmph Speed of second car V_2= 50kmph Reaction time t = 2.5seconds Coefficient of friction = 0.7 Brake efficiency of cars = 50% Stopping site distance for a vehicle is given by SSD = $vt + \frac{v^2}{2gf}$ Where, v is the velocity of the vehicle t is the reaction time of the driver. g is the acceleration due to gravity and f is the coefficient of friction between road and tyre. Here, V_1 = 80kmph = 22.22m/s V_2 = 50kmph = 13.89m/s As the brake efficiency is 50% in order to completely stop the vehicle greater amount of distance will be travelled, to account this the coefficient of friction developed is taken as 50% of the given value.	0.5 1 1.5	8	

	i.e., $f = 0.5 \times 0.7 = 0.35$ Stopping Sight distance of first car is, $SSD_1 = 22.22 \times 2.5 + \dfrac{22.22^2}{2 \times 9.8 \times 0.35}$ $= 55.55 + 71.97$ $= 127.52m$ Stopping Sight distance of second car is, $SSD_2 = 13.89 \times 2.5 + \dfrac{13.89^2}{2 \times 9.8 \times 0.35}$ $= 34.725 + 28.12$ $= 62..85m$ Sight distance to avoid head on collision of two cars = $SSD_1 + SSD_2$ = 127.52 + 62.85 = 190.4m	2 2 1		**15**
V) a.	Gradient is the rate of rise or fall along the length of the road with respect to the horizontal. It is expressed as a ratio of 1 in x (1 vertical unit to x horizontal unit). Some times it is also represented in terms of percentage (eg n%) A positive sign signifies ascending gradient, while negative sign signifies descending gradient. IRC classifies Highway gradients into 4 types • Ruling Gradient • Limiting Gradient • Exceptional Gradient • Minimum Gradient **Ruling Gradient:** It is the desirable upper limit of gradient. Designer attempts to design the vertical profile of road within this gradient. It depends upon type of terrain, length of grade, Speed, Power of vehicle, presence of horizontal curves and mixed traffic. IRC recommends a value of 1 in 30 in plains and 1 in 20 in hills. **Limiting Gradient:** It is gradient steeper than ruling gradient. These are provided in hilly terrains where earthwork becomes difficult there arises a	2 1.5		

	need for providing steeper gradient. Limiting gradient is the limit of the steepest gradient. Stretches of limiting gradients are separated by stretches of level road or easier gradients. IRC recommends a value of 1 in 20 in plains and 1 in 15 in hills. **Exceptional Gradient:** These are gradients steeper than limiting gradients. These are provided in exceptional cases such as approaches to causeways, hair pin bends and in areas of difficult terrain for cutting. They should not be provided for more than 100m in a stretch of 1.6km. IRC recommends a value of 1 in 15 in plains and 1 in 12 in hills. **Minimum Gradient:** Gradient provided on roads to drain off water. This is important only at stretches where surface drainage is important. Camber will take care of the lateral drainage, it is the longitudinal drainage that is achieved using minimum gradient. Minimum gradient depends upon rainfall, type of soil and type of side drain. 1 in 500 is sufficient for concrete drains while 1 in 200 is required for open soil drains.	1.5 1.5 1.5	8	
V) b.	Cross section of road in embankment. 			

	Mark split up: Drawing figure. Marking of CW, ROW, FW, Road Margin and Shoulder Marking of Longitudinal drain, road boundary, setback distance etc.	4 2 1	7	**15**
VI) a.	**Prime Coat:** Application of low viscosity bitumen over the porous or absorbent surface over which bitumen surface is to be laid is called Prime Coat. Its purpose is to seal the pores in the porous surface thereby preventing upward movement of water into the bituminous layer on top. Prime coat is applied first by preparing the road surface to proper grade and level, correcting undulations and drying. Then bitumen primer is applied by spraying on this prepared surface. It is left to cure for 24 hrs. **Tack Coat:** Application of bitumen over impervious or nonporous surface before the application of bitumen layer. Purpose of tack coat is to provide bond between existing surface and the new bituminous surface. Tack coat is applied by first preparing the existing impervious surface by brooming or cleaning and subsequent drying. Then application of straight run bitumen. **Seal Coat:** Seal coat is the thin layer of bituminous surface treatment applied as final protective cover for the wearing surface. The major purpose of seal coat is to increase the resistance to wear and weathering action and to provide a better riding surface. Seal coat is applied over old or freshly prepared bituminous course by first preparing the surface over which seal coat is to be applied, application of bituminous material, application of cover coat by spreading thin layer of sand or grave (6 to 12 mm) and rolling by 6 to 10 tonne roller and finally finishing by checking required grades and levels.	2 2 3	7	

VI) b.

Properties	Flexible	Rigid
Design Principle	Empirical method Based on load distribution characteristics of the components	Designed and analyzed by using the elastic theory
Material	Granular material	Made of Cement Concrete either plan, reinforced or prestressed concrete
Flexural Strength	Low or negligible flexible strength	Associated with rigidity or flexural strength or slab action so the load is distributed over a wide area of subgrade soil.
Normal Loading	Elastic deformation	Acts as beam or cantilever
Excessive Loading	Local depression	Causes Cracks
Stress	Transmits vertical and compressive stresses to the lower layers	Tensile Stress and Temperature Increases
Design Practice	Constructed in number of layers.	Laid in slabs with steel reinforcement.
Temperature	No stress is produced	Stress is produced
Force of Friction	Less. Deformation in the sub grade is not transferred to the upper layers.	Friction force is High
Opening to Traffic	Road can be used for traffic within 24 hours	Road cannot be used until 14 days of curing
Surfacing	Rolling of the surfacing is needed	Rolling of the surfacing in not needed.

Mark splitup – need to write any 8 points of classification.

8

15

VII) a.

Bull Headed Rails (B.H Rails)

<u>Advantages of Bull Headed Rails</u>

1. They keep better alignment and give a more solid and smoother track. 1.5

2. The rails can be easily removed and replaced quickly. Hence renewal of track is easy.

3. The heavy chair with a large bearing on sleepers gives longer life to the wooden sleepers and greater stability to the track.

<u>Disadvantages of Bull Headed Rails</u>

1. They require costly fastenings. 1.5

2. They have less strength and stiffness.

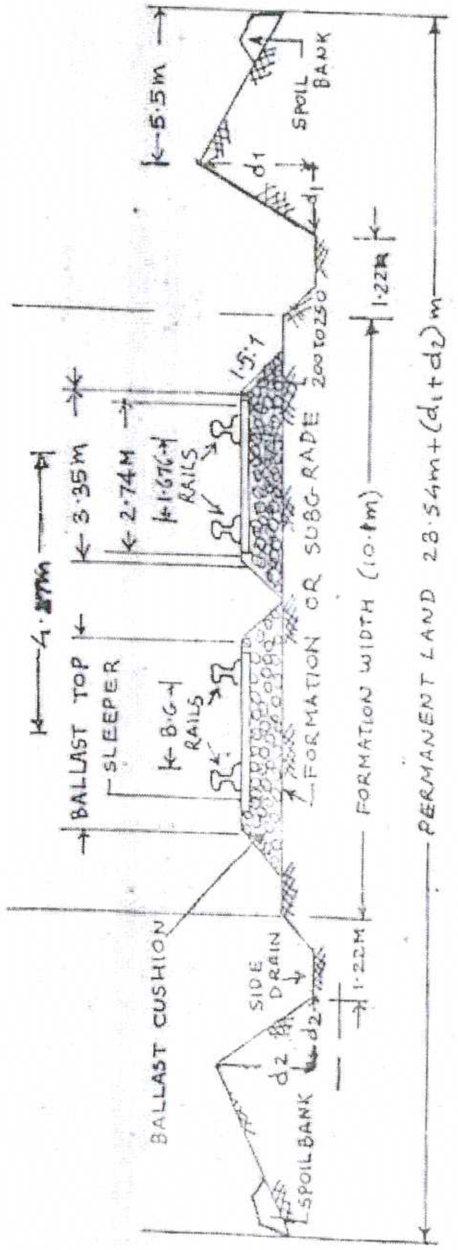
3. They require heavy maintenance cost.

Flat Footed Rails(F.F. Rails)

<u>Advantages of Flat Footed Rails</u>

1. These rails have more strength and stiffness. 1.5

	2. Fitting of rails with sleepers is simpler so they can be easily laid and re-laid. 3. No chairs and keys are required as in case B.H rails. <u>Disadvantages of Flat Footed Rails</u> 1. The fitting get loosened more frequently. 2. The straightening of bent rails, replacing of rails and de-hogging of battered rails are difficult. 3. These rails sink into the wooden sleepers under heavy trainload. Hence they require a bearing plate to overcome this problem.	1.5	6	

	 Cross-Section of Double line Broad Gauge track in cutting			
VII) b.	Splitup – drawing figure Labelling and marking relevant details.	6 3		
VIII) a.	Functions of Sleepers: • Hold the rails to proper gauge in all situations. • Support the rails evenly throughout. • Distribute the load transmitted through rails over large area of ballast underneath.	 1 1 1		

	• Provide elastic medium between rails and ballast and also to absorb the vibrations caused due to moving axle loads. • Provide general stability of the permanent way throughout. • Provide insulation of track for track circuits. • Provide ease in replacement of rail fastening without any serious traffic disturbances.	1 1 1 1	7	
VIII) b.	According to purpose of the yards they are divided into: - Passenger yard - Marshalling yard - Locomotive yard - Goods yard **Passenger yard:** Provided to enable safe movement of passengers to board or alight from the trains. It consist of passenger platform stations building, booking office, waiting rooms, refreshment rooms and facilities such as drinking water, fan etc., **Marshalling yard:** Marshalling yards receive wagons from different centres and they are sorted out and formed into trains for each route and despatched. Marshalling yards are provided at important junction stations. Marshalling yard consist of Reception sliding, Sorting sliding and Despatch sliding. Marshalling yards are further classified as Flat yard, Gravitational yard and Hump yard. **Locomotive yard:** These are yards where locomotives are housed for servicing and repairing Locomotive yard comprises of ash pits, examination pits, turn table, fuel platform and water column. It should be located near the passenger yard and goods yard so that both incoming and outgoing engines take less time. **Goods yard:** These are yards provided to receive goods trains for loading and unloading. It consists of goods platform, goods shed, booking offices, weighing machines, weigh bridges, loading gauge, dead end sidings with buffer stop, sick sidings to station for sick wagons. The platforms must be of sufficient height so that loading and unloading from wagons can be done easily.	2 1.5 1.5 1.5 1.5	8	**15**

	Classification of bridges are as follows:			
	1. According to material used:			
	- Timber bridges			
	- Masonry bridges	1		
	- RCC bridges			
	- Prestressed Concrete Bridges			
	- Steel Bridges			
	2. According to structural action			
	- Beam and slab bridges	1		
	- Truss or girder bridges			
	- Simply supported or continuous or cantilever bridges			
	- Suspension Bridges			
IX) a.	- Arch bridges			
	3. According to alignment			
	- Square or straight bridges			
	- Skew bridges	1	8	
	4. According to location of flooring			
	- Deck bridges			
	- Through bridges	1		
	- Semi through bridges			
	5. According to position of HFL			
	- Submersible bridges			
	- Non submersible bridges	1		
	6. According to span			
	- Culverts			
	- Minor bridge	1		
	- Major Bridge			
	7. According to life			
	- Temporary bridges	1		
	- Permanent bridges			
	8. According to live load standards (IRC)			
	- Class AA- Loading bridges			
	- Class A- Loading bridges	1		
	- Class B- Loading bridges			

IX) b.	- Suitable unyielding, non-erodible material for foundation should be present at shallow depths for piers and abutments. - Stream at bridge site should be steady, well defined and as narrow as possible. - Site should have firm, permanent, straight and high banks. - It should be possible to have straight, economic approach road and square alignment. - There should not be no need of costly river training works in vicinity of bridge site. - For economy, there should be easy availability of labours, transport facilities and construction materials within the vicinity of site. - Site should be such that adequate water way and vertical height is available underneath the bridge.	1 1 1 1 1 1 1	7	**15**
X) a	Factors affecting airport site selection are: - Atmospheric and meteorological conditions: Poor visibility lowers the traffic capacity, hence fog, smoke and haze should be less in the locality. Wind data should be collected for a minimum period of five years, as runway is oriented such that landing and take-off is done heading into the wind. - Availability of land for expansion : When traffic increases, extra runways, more facilities are to be provided. For this a larger area must be acquired in the initial stages. - Use of airport: Site selection depends on civilian or military airport. Even if it is a civilian airport in the need of emergencies this may get taken over by the military. Hence site should provide natural protection to the area from air raids. - Proximity to other airport: Site should be considerably away from existing airports. The aircraft landing in one airport should not interfere the movement in the other airport.	1 1 1 1	8	

	- Availability of utilities: Utilities such as water supply, sewer, telephone, electricity are to be readily available through out from the nearby town. - Accessibility to the ground: Site should be adjacent to main highway. With minimum time taken for passengers from the town centre to reach the airport. - Topography and soil characteristics: Hill top or raised ground is ideal site for an aircraft. The site should have less obstructions in approach zone and turning zone. Sites with high water table may be avoided as the cost of drainage and grading will be more. This cost can be reduced by choosing site with soil having reasonable amount of gravel and sand. - Economic Considerations: Cost estimate are to be prepared considering the land cost, clearing the site, removal of obstructions and hazards, grading of land drainage, paving, turfing, building construction, access roads and car parking. From comparing the cost estimates of all available sites, most economical one is chosen.	1 1 1 1		
X) b.	Harbours are classified into two broad types: - Classification based on protection needed - Classification based on functions performed. Classification based on protection needed: - Natural Harbour: Located in places where topography of the coast is such that a part of sea is protected by land and no artificial protection is required for ships. It consist of part of body of water which is protected and deep enough for anchorage. Example – Bombay and Kandla. - Semi- Natural harbours: These are protected on sides by headlands and it requires man-made protection only at the entrance. Example- Visakapatnam Harbour. - Artificial harbour: Harbours having no natural protection but artificial arrangement to protect the harbour from storm and wind. Area is protected from storm and wind by breakwaters or dredging. Example Madras harbour.	1 3		

	Classification based on Function: - Harbours of refuge: These are harbours used by ships in storms or emergency conditions. They are provided with good anchorage and safe and easy access from the sea. All disabled and damaged ships require quick shelter and immediate repairs and hence must be easily accessible from high seas. - Commercial harbour: These are harbours having facilities for loading and unloading cargo. Along with this dry docks are provided for repairs. Adequate quay space for berthing, receiving and delivering cargo is made available. - Fishery harbour: Also known as fishing harbour, are supposed to be constantly open for arrival and departure of fishing ships. They should have adequate loading and unloading facilities. These harbours also must have provisions for refrigerated stores to store the catch from the sea. - Military Harbour: These harbours are meant for accommodating navel crafts serve as supply depots. Bombay and Cochin harbours have naval bases. Layout of these harbours are greatly influenced by the location and strategic importance.	3	7	**15**