Indian Forest Service (Main)
Examination, 2024

JBNV-B-CVLE

CIVIL ENGINEERING
Paper – II

*Time Allowed : **Three** Hours*	*Maximum Marks : **200***

Question Paper Specific Instructions

Please read each of the following instructions carefully before attempting questions :

*There are **EIGHT** questions divided in **TWO** sections.*

*Candidate has to attempt **FIVE** questions in all.*

*Questions No. **1** and **5** are **compulsory** and out of the remaining, any **THREE** are to be attempted choosing at least **ONE** question from each section.*

The number of marks carried by a question / part is indicated against it.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer (QCA) Booklet must be clearly struck off.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Diagrams / Figures, wherever required, shall be drawn in the space provided for answering the question itself.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

*Answers must be written in **ENGLISH** only.*

SECTION A

Q1. (a) 9 m^3 of concrete mix is to be prepared using 40 bags of cement. As per design, 800 litres of water is to be added. Determine the water – cement ratio. If by mistake, the mason adds more than 800 litres water, how does the increased water – cement ratio influence the properties of concrete ? *8*

(b) What are the various economic factors generally considered for selecting equipment for a construction project ? Also discuss how versatility of the equipment is advantageous in reducing ownership and operating cost of equipment. *8*

(c) What are the important features of 'Resource Smoothing' and 'Resource Levelling' approaches you understand to solve resource allocation problem for a construction project ? *8*

(d) For a plain cement concrete pavement, the coefficient of friction is 1·5, the tensile strength of concrete is 1·2 kg/cm^2, and the unit weight of concrete is 2400 kg/m^3. Determine the spacing of contraction joints in pavement, which will be adopted here, as per Indian specifications. Also determine the spacing between the expansion joints, if expansion joint gap is 2·2 cm, maximum increase in temperature is expected to be 26°C after the pavement construction, and thermal coefficient is 10×10^{-6} per °C. *8*

(e) Levelling was carried out in an area, but while computing the values in the table below, some of values became illegible due to sudden rain drops. Find the missing values and check your answer. Also show computations. *8*

Station	BS (m)	IS (m)	FS (m)	HI (m)	RL (m)	Remarks
1	×			134·600	132·385	BM
2		×			132·995	
3	2·080		0·985	×	×	CP1
4		×			132·940	
5	0·605		×	×	134·440	CP2
6		×			133·070	
7		1·045			×	
8			×		132·360	

Q2. (a) It is proposed to use either equipment A or equipment B to operate an earth pit for a construction project for a period of 6 years. The data regarding equipment A and equipment B are given as follows :

Equipment	Number required for same capacity	Initial cost for each equipment	Operating cost per equipment per year	Salvage value	Service life
A	1	₹ 2·5 lakh	₹ 1·1 lakh	0 at the end of project	6 years
B	4	₹ 0·25 lakh	₹ 0·3 lakh	0 at the end of 4 year service life and ₹ 5000 each equipment for replacement will not be in service for their entire life	4 years

(i) Assuming interest rate is 10 percent, compare present worth of equipment A with all equipment B to be used and determine which equipment, A or B, is to be preferred from present worth point of view ? Assuming equipment B are replaced at the end of 4 years and the replacements will not be in service for their entire useful life, their estimated salvage values (@ ₹ 5000 for each equipment B) must be included as a cash inflow at the end of project in 6 years.

(ii) If equipment B are also available with an initial cost for each equipment at ₹ 0·40 lakh and with a total extended service life of 5 years, determine whether it is to be preferred to use equipment B with extended service life by comparing present worth as obtained in case (i) above. Assume all other data as same as given in case (i) above. *15*

(b) (i) A horizontal curve is to be designed in a hilly terrain for a four-lane road with 3 m width of each lane. The deflection angle of the curve is 50°, and the tangent length is 153 m. The point of intersection is located at a chainage of 5 + 650 m. If the proposed road has a coefficient of side friction as 0·082 and rate of superelevation as 0·09 m/m, determine whether this road section is appropriate for a design speed of 80 kmph; if not, redesign the curve. Compute the chainages of Point of Curve (PC) and Point of Tangency (PT). *10*

(ii) Write the importance of highway drainage as well as the requirements of a good highway drainage system. *5*

(c) A vertical aerial photograph was taken with a camera of 15 cm focal length and 23 cm format photograph. A straight length of highway AB measures 16·25 on this photograph, while its corresponding distance on a map at 1 : 25,000 scale is 6·5 cm. If the average elevation of the terrain is 1200 m above mean sea level, determine the flying height of aircraft at the time of photography. Also compute the ground area covered by one single photograph. *10*

Q3. (a) From a survey station R, whole circle bearings of two stations P and Q, which are inaccessible, were measured as 225°00′ and 153°26′, respectively. The independent coordinates of stations P and Q are given below :

Station	Easting (m)	Northing (m)
P	600	500
Q	700	450

Compute the independent coordinates of station R. *15*

(b) (i) What are the various applications of bulldozers in construction works ? What are the important factors affecting the production rate of bulldozers ? *10*

(ii) What are the advantages and disadvantages of fibre-reinforced concrete over conventional concrete ? *5*

(c) For a speed of 60 kmph, an equilibrium cant is provided on a BG of 5° curve. Calculate the value of equilibrium cant, and maximum permissible speed on the track, allowing the maximum cant deficiency. *10*

Q4. (a) (i) What are the requirements of a material to be used as a damp proofing material ? What are the various materials commonly used in the buildings to prevent capillary rise of water for damp proofing ? *10*

(ii) Briefly discuss the criteria for deciding orientation of residential buildings under hot arid zones of India. *5*

(b) (i) The total cycle time for a given road intersection is 60 seconds; the green time for the phase is 27 seconds and corresponding yellow time is 4 seconds. The saturation headway is 2·4 seconds/vehicle, the startup lost time is 2 seconds/phase, and the clearance lost time is 1 second/phase. Calculate the capacity of intersection. *10*

(ii) A linear relationship between average travel speed of vehicle v (km/hr) and average density k (number of vehicles/km) for a traffic stream on a road is given as $v = 70 - 0{\cdot}7\ k$. Determine the capacity of vehicles on this road. *5*

(c) What are the advantages of using flat slab floors in modern buildings ? What are the various factors to be considered in selecting a flooring type for a ground floor ? *10*

SECTION B

Q5. (a) A stream of 150 litres/second is diverted from a canal and 105 litres/second is diverted to the field. An area of 3 hectares is irrigated in 10 hours. Effective depth of root zone is 1·5 m. The runoff loss in the field is 450 cu.m. The depth of water penetration varies linearly from 2·0 m at the head end of the field to 1·5 m at the tail end. Available moisture holding capacity of the soil is 20 cm per metre depth of soil. Determine : *8*

(i) Water Conveyance efficiency (η_c);

(ii) Water Application efficiency (η_a);

(iii) Water Storage efficiency (η_s); and

(iv) Water Distribution efficiency (η_d).

Irrigation has started at a moisture extraction level of 60% of the available moisture.

(b) Discuss briefly, at least four types of spillways. *4×2=8*

(c) (i) The impounding reservoir has original storage capacity of 738 ha-m. The drainage area of reservoir is 80 km^2, from which, annual sediment discharges into the reservoir at the rate 0·1153 ha-m/km^2 of the drainage area. Assuming the average trap efficiency as 80%, find the annual capacity loss of the reservoir. Find percentage loss per decade. *4*

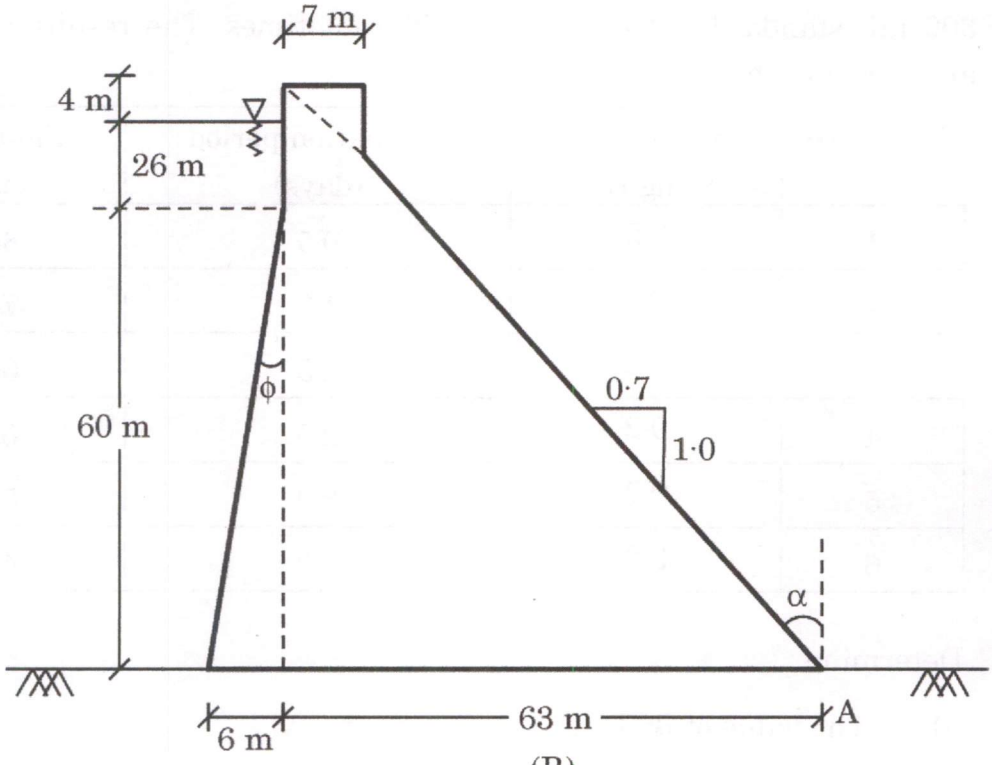
(ii) Estimate the fire demand of water for a city having a population of 500000. Use Freeman formula, Kuichling formula, and National Board of Fire Underwriters formula. What is the average fire demand for Indian conditions ? *4*

(d) Describe the sources and impacts of physical impurities in potable water sources. *8*

(e) Which inorganic gases cause significant air pollution ? Describe their important characteristics and sources. *8*

Q6. (a) An impervious floor of a weir on permeable soil is 16 m long and has sheet piles at both the ends. The upstream pile is 4 m deep and the downstream pile is 5 m deep. The weir creates a net head of 2·5 m. Neglecting the thickness of the weir floor, calculate the uplift pressure at the junction of the inner faces of the piles with the floor, by using Khosla's theory. Also, draw simple (upstream and downstream) profiles with salient points. *15*

(b) Determine the magnitude of maximum compressive stress and maximum shear stress that may develop under the reservoir empty condition of a concrete dam shown in the figure below. Take unit weight of concrete as 24 kN/m^3. Reservoir is empty without tail race and no sedimentation on the upstream face of the dam. Consider moments about point A. *15*



(B)

(c) A continuous flow settling tank has an effective water depth of 3 m and is 50 m long. Determine the flow velocity of water for removal of 0·03 mm particles at 25°C temperature. Take specific gravity of particles as 2·65, kinematic viscosity of water as 0·01 cm^2/s, β = 0·04 for unigranular sand, and f = 0·025, friction factor. *10*

Q7. (a) A town with a population of 200000 is to be supplied with water daily at 300 litres per head.

The variation of demand is given below :

6 am to 9 am	–	30% of total
9 am to 12 noon	–	15% of total
12 noon to 3 pm	–	15% of total
3 pm to 6 pm	–	15% of total
6 pm to 9 pm	–	25% of total

Determine, by using the mass curve method, the capacity of the service reservoir assuming pumping to be at a uniform rate and the pumping period is to be from 6 am to 6 pm. Neglect fire demand. *15*

(b) BOD tests were performed on 4 mL samples of a wastewater using 300 mL standard BOD bottles at different times. The results obtained are shown in the table below :

Bottle No.	Initial DO in mg/L	Incubation period (days)	Final DO (mg/*l*)
1	9·2	0·5	8·3
2	9·2	1·0	7·3
3	9·2	1·5	6·6
4	9·2	2·0	6·1
5	9·2	3·0	5·1
6	9·2	5·0	4·0

Determine : *15*

(i) The value of BOD rate constant per day.

(ii) The value of 5 day BOD.

(iii) The oxygen equivalent of organic matter present in wastewater at the start of BOD reaction.

Use Thomas graphical method.

(c) The mass curve of rainfall in a storm of total duration 100 minutes is given below :

Time (minutes)	Cumulative rainfall (mm)
0	0
20	6
40	22
60	33
80	37
100	40

(i) Draw the hydrograph of the storm at 20 minutes time step;

(ii) Plot the maximum-intensity-duration curve for the storm; and

(iii) Plot the maximum-depth-duration curve for the storm. *10*

Q8. (a) An extensive aquifer is known to have a groundwater flow N 30° E direction. Three wells P, Q and R are drilled to tap these aquifers. Well Q is East of P and well R is North of P. Estimate the elevation of water table at well R, with the following data regarding these wells, when the wells are not pumping. Also draw the layout of the wells. *10*

Distance (m)	Well	Ground surface elevation (m) (above datum)	Water table elevation (m) (above datum)
	P	160·00	157·00
PQ = 800	Q	159·00	156·50
PR = 2000	R	158·00	?

The canal is of clean gravel with coefficient of permeability (K) as 100 cm/second. Find the resultant velocity of flow.

(b) The ordinates of 2-hour Unit Hydrograph (UH) are given below. Derive the 6-hour UH for the same catchment. Also draw to a scale, the resulting UH. *10*

Time (hr)	Ordinates of 2-UH
0	0
2	40
4	100
6	50
8	10
10	0

(c) Design a standard egg-shaped sewer pipe-section for a combined storm water-sewage flow for a residential colony. Following data is given :

Area of colony : 30 hectares

Population : 20,000

Per capita water consumption : 200 *l*phd

Critical design rainfall intensity : 4 cm/hr

General available ground slope : 1 in 900

Coefficient of runoff for the area : 0·55

Manning's coefficient for the pipe : 0·013

Assume :

(i) 80% of water consumed appears as sewage.

(ii) Peak sewage discharge = 3 times the average discharge.

Also draw neat sketch of the sewer section. *10*

(d) Following is the composition of a hard water sample :

Free carbon dioxide = 4 mg/L

Alkalinity = 72 mg/L

Non-carbonate hardness = 100 mg/L

Total magnesium = 18 mg/L

Assume that it is possible to remove all but 38 mg/L of carbonate hardness with lime and that the treated water is to have a total hardness of 85 mg/L. Determine the amount of hydrated lime and soda required for treatment per million litres of raw water. Take atomic mass of : Ca = 40; Mg = 24, C = 12; O = 16; Na = 23; H = 1. *10*