# Engineering Services (Main) Examination, 2026

**SNCS–T–CVLE**

## CIVIL ENGINEERING

PAPER—II

| Time Allowed : Three Hours | Maximum Marks : 300 |
|---|---|

### 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.

Question Nos. **1** and **5** are **compulsory** and out of the remaining, **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.

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.

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.

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

## SECTION—A

**1.** *(a)* The following observations were made for conducting the water budget of a reservoir over a period of one month of 31 days :

Average surface area = 10 $km^2$

Rainfall = 10 cm

Mean surface inflow = 10 $m^3/s$

Mean surface outflow = 15 $m^3/s$

Fall in reservoir level = 1·50 m

Pan evaporation = 20 cm

Pan coefficient = 0·70

Estimate the average seepage discharge during that month. 12

*(b)* In a recuperation test of a 3 m diameter open well, the water level changed from 114·60 m to 115·70 m elevation in 120 minutes. If the water table elevation is 117·00 m, determine *(i)* the specific capacity per unit well area of the aquifer and *(ii)* the discharge in the well under a safe drawdown of 2·75 m. *(iii)* What would be the yield from a well of 4 m diameter for a drawdown of 2·50 m? 12

*(c)* A rectangular channel 2 m wide has a flow of 2·5 $m^3/s$ at a depth of 1·0 m. Determine whether critical depth occurs at a section where a hump of height $h = 0·2$ m is installed across the channel bed. 12

*(d)* The $BOD_5$ of a water sample from a polluted river is determined to be 250 mg/L at 20 °C. The *k*-value is known to be 0·23 per day. What would be the $BOD_8$, if all tests were run in an air-conditioned laboratory at 15 °C ? 12

*(e)* Enumerate any six measures to limit air pollution at a construction site and describe each in one sentence. 12

**2.** *(a)* *(i)* Backwash operation is an important operation at a water treatment plant. Compute the quantity and percentage of treated water used in washing as also the rate of wash water flow in each trough. The following data are known :

The size of filter unit is 4·0 m × 10·0 m. After filtering 12000 cubic metres of water in a 24-hour period, the filter is backwashed at the rate of 12 litres/sq. m/s for 15 minutes. There are 3 troughs. 10

*(ii)* Determine the dimensions of a channel-type grit chamber to remove particles with a diameter of 0·2 mm and specific gravity of 2·65. Assume a settling velocity of 0·018 m/s. The flow-through velocity of 0·35 m/s is maintained by a proportioning weir. Given that the maximum wastewater flow is 12000 $m^3$/day and that a rectangular cross-section with depth = 1·5 × width at maximum flow is desired. 10

(b) Consider a water pump discharging at a rate of 0·30 $m^3/s$. The diameters of the discharge and suction nozzles are 300 mm and 350 mm respectively. The reading on the discharge gauge located 0·30 m above the centreline of the impeller is 156·96 $kN/m^2$, while the reading on the suction gauge located at the centreline of the impeller is 19·620 $kN/m^2$. Given that the efficiencies of the pump and motor are 60 percent and 88 percent respectively.

Take : $\gamma = 9810\ N/m^3$

$g = 9 \cdot 81\ m/s^2$

The reference datum is the centreline of the pump impeller.

Determine—

(i) the total dynamic head;

(ii) the power input required by the pump;

(iii) the power input to the motor. 20

(c) The drag force $F$ on a smooth sphere depends on the relative speed $V$, the sphere diameter $D$, the fluid density $\rho$, and the fluid viscosity $\mu$. Using Buckingham $\pi$ theorem, obtain a set of dimensionless groups that can be used to correlate experimental data. 20

**3.** (a) (i) Solid wastes from construction and demolition sites can be utilized beneficially by civil engineers. Enumerate five such uses and briefly describe each in one or two sentences. 10

(ii) Briefly describe the rotating biological contactor system for municipal wastewater treatment with the help of a sketch. What are its advantages and disadvantages? 10

(b) (i) Differentiate between the following in a few lines :

(I) Regular meanders and Irregular meanders

(II) Aggradation and Degradation in rivers

(III) Attracting and Repelling spurs

(IV) Tidal rivers and Delta rivers

(V) Weirs and Flumes 2×5=10

(ii) What is a canal outlet? What are the requirements to be satisfied by a canal outlet for its proper functioning? Enlist the factors on which the choice of type of outlet and its design are governed. Describe the three types of canal outlets, each in a few lines. 10

(c) (i) With the help of a sketch, briefly explain boundary layer separation. 10

(ii) What are the disadvantages of boundary layer separation? In which hydraulic devices does it occur? 5

(iii) What are the methods to control separation of boundary layer? 5

**4.** *(a)* Sketch the schematic of an activated sludge reactor. It is planned to design an activated sludge system for secondary treatment of 12000 $m^3$/day of municipal wastewater. The BOD after primary clarification is 154 mg/L and the soluble BOD in the effluent should not be more than 4 mg/L. A completely mixed reactor is to be used, and a pilot plant study has given the following values :

$$Y = 0 \cdot 5 \text{ kg/kg}$$
$$k_d = 0 \cdot 05/\text{day}$$
$$\theta_c = 10 \text{ days}$$

Assuming an MLSS concentration of 4000 mg/L and an underflow concentration of 10000 mg/L from the secondary clarifier, determine—

*(i)* the volume of the reactor;

*(ii)* the mass;

*(iii)* the volume of solids that must be wasted each day;

*(iv)* the recycle ratio. 20

*(b)* A new township is to be set up to house 40000 people for a new dam. The water for this township has to be sourced from a river 4 km away into a storage reservoir using pumps. The maximum difference of levels of water between the river and reservoir is 20 m. The water supply is limited to 100 litres per person per day. The pumps will be operated only 6 hours per day in two shifts. Given that the efficiency of the pumps is 76%. Determine the horsepower of the pumps. Given : Friction factor = 0·03 and velocity of flow = 2·5 m/s, maximum daily demand is 1·5 times the average daily demand, available pipe diameters 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 700 (in mm), $g = 9 \cdot 81$ m/$s^2$ and $\gamma_w = 9 \cdot 81$ kN/$m^3$. 20

*(c)* The following are the data of gauge and discharge collected at a particular section of the river by stream gauging operation. Develop a gauge-discharge relationship for this stream at this section for estimating the discharge for a known gauge reading. What is the coefficient of correlation of the desired relationship? Assume the value of gauge reading for zero discharge as 35·00 m. Estimate the discharge corresponding to a gauge reading of 42·50 m at this section.

(*Note* : The gauge-discharge relationship is of the form $Q = C_r (G - a)^{\beta}$, where $Q$ is the discharge corresponding to a given gauge reading $G$, $a$ is a constant representing the gauge reading corresponding to zero discharge, $C_r$ and $\beta$ are rating curve constants.)

| *Gauge reading* (m) | *Discharge* ($m^3$/s) | *Gauge reading* (m) | *Discharge* ($m^3$/s) |
|---|---|---|---|
| 35·91 | 89 | 45·40 | 4560 |
| 36·90 | 230 | 46·43 | 5305 |

| | | | |
|---|---|---|---|
| 37·92 | 360 | 48·02 | 5900 |
| 39·07 | 469 | 49·05 | 6800 |
| 41·00 | 798 | 49·55 | 6900 |
| 43·53 | 2800 | 49·68 | 6950 |
| 44·40 | 3800 | — | — |

20

## SECTION—B

**5.** *(a)* In a Casagrande's apparatus, liquid limit test was performed and the following results were obtained :

| *No. of blows* | 49 | 39 | 30 | 21 | 15 |
|---|---|---|---|---|---|
| *Water content* (%) | 33·1 | 36·0 | 41·2 | 46·0 | 53·0 |

If the shrinkage limit and shrinkage index are 16% and 9% respectively, determine the toughness index and comment on the nature of soil. Also classify the soil as per the Indian standard. 12

*(b)* Draw the influence lines for the vertical stress and shear stress intensities at a depth of 2 m below the ground level due to concentrated point load of 100 kN applied on the ground surface. 12

*(c)* The radius of a horizontal curve is 400 m, the total pavement width at curve is 7·6 m and the superelevation is 0·07. Design the transition curve length for a speed of 100 kmph. Assume the pavement to be rotated about the inner edge. Allow a rate of change of superelevation of 1 in 150. 12

*(d)* The length of a runway at sea-level, standard atmospheric conditions and zero gradient is 1500 m. The airport site has an elevation of 900 m, and the reference temperature is 20 °C. If the proposed runway grading permits an effective gradient of 0·20 percent, determine the actual runway length required at the site. The ICAO recommends that the basic runway length should be increased at the rate of 7% per 300 m rise in elevation above the mean sea level. The ICAO recommends that the length corrected for elevation should further be increased at the rate of 1% for every 1 °C by which the airport reference temperature exceeds the temperature in the standard atmosphere for the airport elevation. The standard temperature at the site refers to the temperature obtained by reducing the standard sea-level temperature of 15 °C at the rate of 6·5 °C per 1000 m rise in elevation. Check whether the total correction for elevation and temperature exceeds the limiting value prescribed by the ICAO. 12

(e) (i) Define the following terms :

(I) Spectral resolution in remote sensing

(II) Nonspatial data in GIS

(III) Multipath error in GPS

(IV) Faults and folds in rocks

(V) Celestial sphere in astronomy

(VI) Geodetic survey 1×6=6

(ii) A vertical aerial photograph was taken with a camera of 21 cm focal length. On this photograph, a pipeline lying on a flat terrain appears as 125 mm long, while the same measures 500 m long on the ground. A TV tower also appears on the photograph and its top and bottom images are 8·7 cm and 7·2 cm away from the principal point respectively. Determine the height of the TV tower. 6

**6.** (a) (i) Three aircrafts *A*, *B* and *C* left an airport at 6:00 AM, 6:10 AM and 6:20 AM at speeds 300 kmph, 360 kmph and 450 kmph respectively. If the aircrafts *A*, *B* and *C* left at reduced bearing N 60° E, S 76° E and S 16° E respectively, determine the reduced bearing of lines *BA* and *BC*, and the distances *AB* and *BC*, as observed from *B* at 7:00 AM. 10

(ii) Between two straight lines, a railway curve of 600 m radius is to be designed. The chainage of point of intersection is (108+09), and the deflection angle is 30°. Determine the tangent length, apex distance, length of curve, and the chainages of the beginning, vertex and end points of the curve. Take one chainage length as 30 m. 10

(b) (i) Calculate the maximum permissible load that a BG locomotive with three pairs of driving wheels bearing an axle load of 20 tonnes each can pull on a straight level track at a speed of 120 kmph. Also calculate the reduction in speed if the train has to run on a rising gradient of 1 in 100. What would be the further reduction in speed if the train has to negotiate a 2° curve on the rising gradient? Assume the coefficient of friction to be 0·2. The following table summarizes the various resistances faced by the train :

| *Nature of resistance* | *Value of resistance* |
|---|---|
| Resistance due to friction | 0·0016 $W$ |
| Resistance due to wave action, track irregularities, and speed | 0·00008 $W$ |
| Resistance due to wind | 0·0000006 $WV^2$ |
| Resistance due to gradient | $\frac{W \times \%\ \text{slope}}{100}$ |
| Curve resistance for BG | 0·0004 $WD$ |

*Note* : $W$ is the total weight of the locomotive and vehicle in tonnes.

$V$ is the speed in kmph.

$D$ is the degree of the curve. 15

*(ii)* What is the use of braking test conducted on a highway? Indicate the measurements needed during such a braking test. 5

*(c)* Two footings, each $2 \cdot 5$ m $\times 2 \cdot 5$ m, 5·5 m apart centre-to-centre, are placed on top of a sandy soil 3 m thick. The load carried by each footing is 1000 kN. Determine the consolidation settlement of the clay layer 1·5 m thick, underlying the sandy layer. The water table is at the base of the footing. The geotechnical properties of the soils are as follows :

*For sandy soil*

Specific gravity $= 2 \cdot 65$

Bulk density $= 19 \cdot 0$ kN/m$^3$

*For clayey soil*

Bulk density $= 16 \cdot 5$ kN/m$^3$

Liquid limit $= 42\%$

Void ratio $= 0 \cdot 80$

Assume that the load is distributed in the soil at 2:1 ratio. 20

**7.** *(a)* A soil sample is procured from the site and tested in a triaxial apparatus under consolidated undrained condition. The sample was consolidated at a cell pressure of 200 kN/m$^2$ and a back saturation pressure of 100 kN/m$^2$ for 24 hours. On the next day, the cell pressure was increased to 300 kN/m$^2$, which resulted in the development of a pore pressure of 10 kN/m$^2$. The axial stress was then gradually increased to 400 kN/m$^2$, which resulted in a failure of the soil sample. The pore pressure recorded at failure was 50 kN/m$^2$. Determine the Skempton's pore pressure parameters $A$ and $B$. 20

*(b)* *(i)* A canal 5 m deep runs through a soil with the following geotechnical properties :

Cohesion $= 18 \cdot 5$ kN/m$^2$

Angle of shearing resistance $= 10°$

Void ratio $= 0 \cdot 75$

Specific gravity $= 2 \cdot 74$

The angle of slope of the bank = 45°

Determine the factor of safety, with respect to cohesion—

(I) when the canal runs full up to the top of banks;

(II) during sudden drawdown condition.

The Taylor's stability numbers for the given slope are as follows :

| *Angle of shearing resistance* | 10° | 5° |
|---|---|---|
| *Stability number* | 0·108 | 0·137 |

Also comment on the factor of safety for the above two conditions of the canal. 10

*(ii)* A group of driven piles is proposed to support mat foundation in loose sand. The group of piles consists of 9 piles, each of diameter 250 mm and length 10 m. The spacing of piles is 1·4 m c/c. The results of SPT values as obtained from the site are as follows :

| *Depth* (m) | 2·0 | 4·0 | 6·5 | 8·0 | 9·0 | 10·0 |
|---|---|---|---|---|---|---|
| *SPT value* | 8 | 11 | 7 | 10 | 7 | 6 |

Determine the capacity of the pile group. 10

*(c)* *(i)* Bring out the essentials of railway track maintenance. Through packing is one of the major maintenance operations performed in a calendar year as part of track maintenance. Describe, in brief, how through packing is carried out in a systematic and sequential manner. 10

*(ii)* What are breakwaters? Explain briefly their types indicating their suitability. 10

**8.** *(a)* Calculate the equivalent *C*-value of a three-layered pavement section having individual *C*-values as given below :

| *Material* | *Thickness* (in cm) | *C-value* |
|---|---|---|
| Bituminous concrete | 10 | 60 |
| Cement-treated base | 20 | 225 |
| Gravel sub-base | 10 | 15 |

10

*(b)* What is the role of cohesive non-swelling (CNS) layer in stabilizing slopes and cuts in embankment? 10

*(c)* *(i)* What is stabilization of boreholes? 10

*(ii)* What are the tests required for the identification of expansive soils? Explain any two tests. 10

*(d)* *(i)* The following consecutive readings are taken with a level instrument and 4 m long levelling staff, on a continuously sloping ground line *AB* at a regular distance of 20 m :

0·352, 0·787, 1·832, 2·956, 3·758, 0·953, 1·756,
2·738, 3·872, 0·812, 2·325, 3·137 (in m)

Enter the above readings in tabular form and compute the reduced level of all the points by rise and fall method, and the gradient of line *AB*, if the reduced level of point *A* is 320·288 m. Apply usual checks. 10

*(ii)* Draw a neat sketch and explain the procedure to layout a culvert on the ground. 10

★★★