CIVIL ENGINEERING

ESE TOPICWISE

CONVENTIONAL SOLVED PAPER-II

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Office: F-126, (Lower Basement), Katwaria Sarai, New Delhi-110 016
Phone: 011-2652 2064 ▪ **Mobile:** 81309 09220, 97118 53908
Email: info.publications@iesmaster.org, info@iesmaster.org
Web: iesmasterpublications.com, iesmaster.org

IES MASTER PUBLICATION

F-126, (Lower Basement), Katwaria Sarai, New Delhi-110016

Phone : 011-26522064, **Mobile :** 8130909220, 9711853908

E-mail : info.publications@iesmaster.org

Web : iesmasterpublications.com

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PREFACE

Engineering Services Exam (ESE) is one of most coveted exams written by engineering students aspiring for reputed posts in the various departments of the Government of India. ESE is conducted by the Union Public Services Commission (UPSC), and therefore the standards to clear this exam too are very high. To clear the ESE, a candidate needs to clear three stages – ESE Prelims, ESE Mains and Personality Test.

It is not mere hard work that helps a student succeed in an examination like ESE that witnesses lakhs of aspirants competing neck to neck to move one step closer to their dream job. It is hard work along with smart work that allows an ESE aspirant to fulfil his dream.

After detailed interaction with students preparing for ESE, IES Master has come up with this book which is a one-stop solution for engineering students aspiring to crack this most prestigious engineering exam. The book includes previous years' solved conventional questions segregated subject-wise along with detailed explanation. This book will also help ESE aspirants get an idea about the pattern and weightage of questions asked in ESE.

IES Master feels immense pride in bringing out this book with utmost care to build upon the exam preparedness of a student up to the UPSC standards. The credit for flawless preparation of this book goes to the entire team of IES Master Publication. Teachers, students, and professional engineers are welcome to share their suggestions to make this book more valuable.

Mr. Kanchan Kumar Thakur
Director–IES Master

CONTENT

CHAPTER 1

WATER DEMAND, ITS SOURCE & CONVEYANCE

Q-1: ***For a town with a population of 2 lakhs, a water supply scheme is to be designed. The maximum daily demand may be assumed as 200 litre/capita/day. The storage reservoir is situated 5 km away from the town Assuming loss of head from source to town as 10 m and coefficient of friction for the pipe material as 0.012, recommend the size of supply main 50% of daily demand has to be pumped in 8 hours for the proposed scheme.*** ***[12 Marks, IES-1996]***

Sol: **Given data:**

Population = 200000

Maximum daily demand = 200 litre/capita/day

Length of pipe, L = 5 km = 5000 m

Head loss, h_L = 10 m

Coefficient of friction for pipe material,

$f' = 0.012$

Friction factor, $f = 4f' = 0.048$

Discharge for which supply main is to be designed (Q) is the 50% of daily demand being pumped in 8 hrs.

Total daily demand = 200000 × 200 = 4× 10^7 litres

$$\therefore \quad Q = \frac{4 \times 10^7 \times 0.5}{8 \times 60 \times 60} = 694.44 \text{ lit/sec.}$$

$$= 0.694 \text{ m}^3\text{/sec.}$$

As per Darcy Weisbach equation,

$$h_L = \frac{fLV^2}{2gD} = \frac{fL(Q/A)^2}{2gD}$$

and

$$A = \frac{\pi D^2}{4}$$

$$\therefore \quad h_L = \frac{8fLQ^2}{\pi^2 g D^5}$$

$$\Rightarrow \quad D^5 = \frac{8 \times 0.048 \times 5000 \times 0.694^2}{\pi^2 \times 9.81 \times 10}$$

$$D = 0.991 \text{ m}$$

Thus adopt size of supply main as 1m.

Q-2: ***Water has to be supplied to a town with one lakh population at the rate of 150 litres/capita/ day from a river 2000 m away. The difference in elevation between the lowest water level in the sump and reservoir is 40 m. If the demand has to be supplied in 8 hours, determine the size of the main and the brake horse power of the pumps required. Assume maximum demand as 1.5 times the average demand. Assume f = 0.03, velocity in the pipe 2.4 m/s and efficiency of pump 80 percent.***
[15 Marks, IES-1997]

Sol: **Data given:**

Population of town = 100000

Consumption per capita per day = 150 litre/capita/day

Length of pipe, L = 2000 m

Friction factor, f = 0.03

Velocity in pipe, v = 2.4 m/s

Efficiency, η = 80%

Calculation for size of the supply main.

Average daily demand = $100000 \times 150 = 15 \times 10^6$ litre/day

This has to be supplied in 8 hours

$$\therefore \quad \text{Average daily discharge} = \frac{15 \times 10^6 \times 10^{-3}}{8 \times 60 \times 60} = 0.5208 \text{ m}^3/\text{s}$$

Maximum discharge, $Q = 1.5 \times \text{Average discharge} = 1.5 \times 0.5208$

$= 0.781 \text{ m}^3/\text{s}$

Let the diameter of supply main = D

We know that,

Discharge, Q = Area × Velocity (v)

$$\Rightarrow \quad \frac{\pi D^2}{4} \times 2.4 = 0.781$$

$$\therefore \quad D = 0.644 \text{ m}$$

Calculations for Brake Horse Power (BHP) of pump :

Using Darcy Weisbach Equation

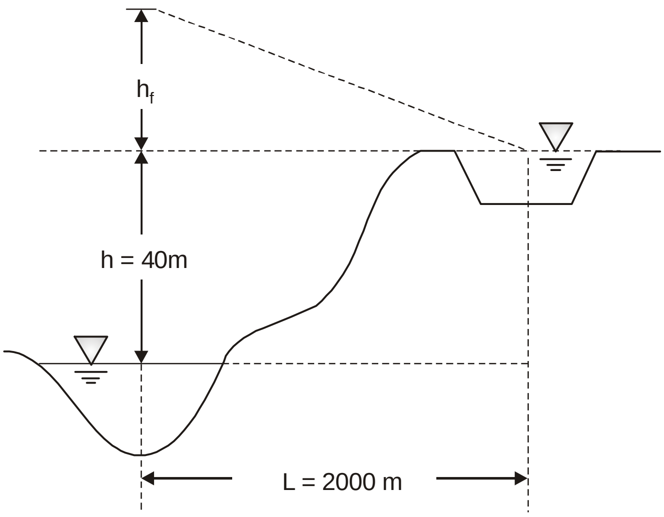
$$h_f = \frac{fLv^2}{2gD} = \frac{0.03 \times 2000 \times 2.4^2}{2 \times 9.81 \times 0.644}$$

$$\Rightarrow \quad h_f = 27.352 \text{ m}$$

$\therefore$ Total head against which pump will lift the water,

$$H = h + h_f = 40 + 27.352$$

i.e. $H = 67.352$ m



$$\therefore \quad \text{Power required} = \gamma Q H$$

$= 9.81 \times 0.781 \times 67.352$

$= 516.19$ KW

Efficiency of pump $= 80\%$

$\therefore$ Pumping power required $= \dfrac{516.19}{0.8} = 645.24$ KW

or Brake Horse Power of pump $= \dfrac{645.24 \times 1000}{745.7}$

$= 865.28$ BHP

Q-3: ***A town of 2,00,000 population is to be supplied water from a source 2500 m away. The lowest water level in the source is 15 m below the water works of the town. The demand of water is estimated as 150 litres/capita/day. A pump of 300 HP is operated for 15 hours. If the maximum demand is 1.5 times the average demand, the velocity of flow through the rising main is 1.3 m/sec and the pump efficiency is 70%, determine***

(i) the hydraulic gradient and

(ii) friction factor for the pipe ***[15 Marks, IES-1999]***

Sol: (i) Daily average demand = Population × per capita demand

$= 2{,}00{,}000 \times 150$

$= 30$ MLD

Maximum demand $= 1.5 \times$ Average demand $= 1.5 \times 30$

$= 45$ ML

This demand is to be supplied in 15 hours

Thus corresponding discharge, $Q = \dfrac{45 \times 10^6 \times 10^{-3}}{15 \times 60 \times 60} = 0.833 \text{ m}^3/\text{sec}$

Efficiency of pump, $\eta = 70\%$

Power of pump $= 300$ HP $= 300 \times 745.7$

$= 223710$ W

$\therefore \quad 223710 = \dfrac{\gamma_w \cdot QH}{\eta}$ [H = total head generated by pump]

$\therefore \quad H = \dfrac{0.7 \times 223710}{9.81 \times 0.833 \times 10^3} = 19.156 \text{ m}$

We know that,

H = (Head difference between source and water works of town) + (Head loss due to friction in rising main)

$\Rightarrow \quad 19.156 = 15 + h_f$

$\Rightarrow \quad h_f = 4.156$ m

Thus hydraulic gradient $= \dfrac{h_f}{L} = \dfrac{4.156}{2500}$

$= 1$ in 601.6

(ii) As per Darcy Weisbach equation:

$$h_f = \frac{fLV^2}{2gD}$$

$\Rightarrow$ We know that,

Area × Velocity = Discharge

$\Rightarrow \quad \frac{\pi D^2}{4} \times 1.3 = 0.833$

$\Rightarrow$ Diameter of rising main, $D = 0.903$ m

Hence, $4.156 = \frac{f \times 2500 \times 1.3^2}{2 \times 9.81 \times 0.903}$

$\Rightarrow$ Hence, $4.156 = \frac{f \times 2500 \times 1.3^2}{2 \times 9.81 \times 0.903}$

$\Rightarrow$ Friction factor of pipe, $f = 0.0174$

Q-4: The census record of a particular town shows the population figures as follows :

Year	*Population*
1960	***55,500***
1970	***63,700***
1980	***71,300***
1990	***79,500***

Estimate the population for the year 2020 by decreasing rate of growth. [10 Marks, IES-1999]

Sol: Average decrease in the percentage increase in population is calculated below:

Year	Population	Increase in population	Percentage-increase in population (r)	Decrease in percentage increase in population
1960	55,500			
		8200	14.77	
1970	63,700			2.84
		7600	11.93	
1980	71,300			0.43
		8200	11.5	
1990	79,500			

$\therefore$ Average value of decrease in percentage increase in population, $r' = \frac{2.84 + 0.43}{2} = 1.635\%$

Rate of growth of population for period 1990 – 2000, $r = 11.5 - 1.635 = 9.865\%$

Population at end of year 2000, $P_{2000} = P_{1990}\left[1 + \frac{9.865}{100}\right] = 79500 \times 1.09865 = 87{,}343$

Rate of growth of population for period 2000 – 2010, $r = 9.865 - 1.635 = 8.23\%$

Population at end of year 2010, $P_{2010} = P_{2000}\left[1 + \frac{8.23}{100}\right] = 87{,}343 \times 1.0823 = 94532$

Rate of growth of population for period 2010 – 2020 = $8.23 - 1.635 = 6.595\%$

$\therefore$ Population for the year 2020, $P_{2020} = P_{2010} \times \left[1 + \frac{6.595}{100}\right] = 94532 \times 1.06595 = 100767$

Q-5: Compute the 'fire demand' for a city of 2 lac population by any two formulae including that of the National Board of Fire Underwriters. [8 Marks, IES-2007]