

# CIVIL ENGINEERING

## ESE TOPICWISE

### CONVENTIONAL SOLVED PAPER-II

1995-2021



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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



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# 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:

$$\text{Population} = 200000$$

$$\text{Maximum daily demand} = 200 \text{ litre/capita/day}$$

$$\text{Length of pipe, } L = 5 \text{ km} = 5000 \text{ m}$$

$$\text{Head loss, } h_L = 10 \text{ m}$$

Coefficient of friction for pipe material,

$$f' = 0.012$$

$$\text{Friction factor, } f = 4f' = 0.048$$

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

$$\text{Total daily demand} = 200000 \times 200 = 4 \times 10^7 \text{ litres}$$

$$\therefore Q = \frac{4 \times 10^7 \times 0.5}{8 \times 60 \times 60} = 694.44 \text{ lit/sec.}$$
$$= 0.694 \text{ m}^3/\text{sec.}$$

As per Darcy Weisbach equation,

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

and

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

$\therefore$

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

$\Rightarrow$

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

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

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,  $L = 2000$  mFriction factor,  $f = 0.03$ Velocity in pipe,  $v = 2.4$  m/sEfficiency,  $\eta = 80\%$ **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

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

$$\begin{aligned} \text{Maximum discharge, } Q &= 1.5 \times \text{Average discharge} = 1.5 \times 0.5208 \\ &= 0.781 \text{ m}^3/\text{s} \end{aligned}$$

Let the diameter of supply main =  $D$ 

We know that,

Discharge,  $Q = \text{Area} \times \text{Velocity} (v)$ 

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

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

**Calculations for Brake Horse Power (BHP) of pump :**

Using Darcy Weisbach Equation

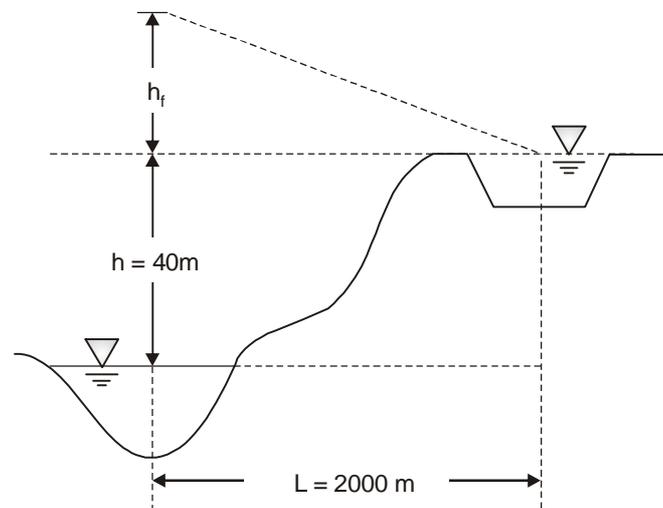
$$h_f = \frac{fLv^2}{2gD} = \frac{0.03 \times 2000 \times 2.4^2}{2 \times 9.81 \times 0.644}$$

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

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

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

$$\text{i.e. } H = 67.352 \text{ m}$$



$$\therefore \text{Power required} = \gamma QH$$

$$\begin{aligned}
 &= 9.81 \times 0.781 \times 67.352 \\
 &= 516.19 \text{ KW} \\
 \text{Efficiency of pump} &= 80\% \\
 \therefore \text{Pumping power required} &= \frac{516.19}{0.8} = 645.24 \text{ KW} \\
 \text{or Brake Horse Power of pump} &= \frac{645.24 \times 1000}{745.7} \\
 &= 865.28 \text{ BHP}
 \end{aligned}$$

**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  $\times$  per capita demand  
 $= 2,00,000 \times 150$   
 $= 30 \text{ MLD}$   
 Maximum demand = 1.5  $\times$  Average demand = 1.5  $\times$  30  
 $= 45 \text{ ML}$

This demand is to be supplied in 15 hours

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

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

Power of pump = 300 HP = 300  $\times$  745.7  
 $= 223710 \text{ W}$

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

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

We know that,

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

$\Rightarrow 19.156 = 15 + h_f$

$\Rightarrow h_f = 4.156 \text{ m}$

Thus hydraulic gradient =  $\frac{h_f}{L} = \frac{4.156}{2500}$   
 $= 1 \text{ in } 601.6$

(ii) As per Darcy Weisbach equation:

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

$\Rightarrow$  We know that,

Area  $\times$  Velocity = Discharge