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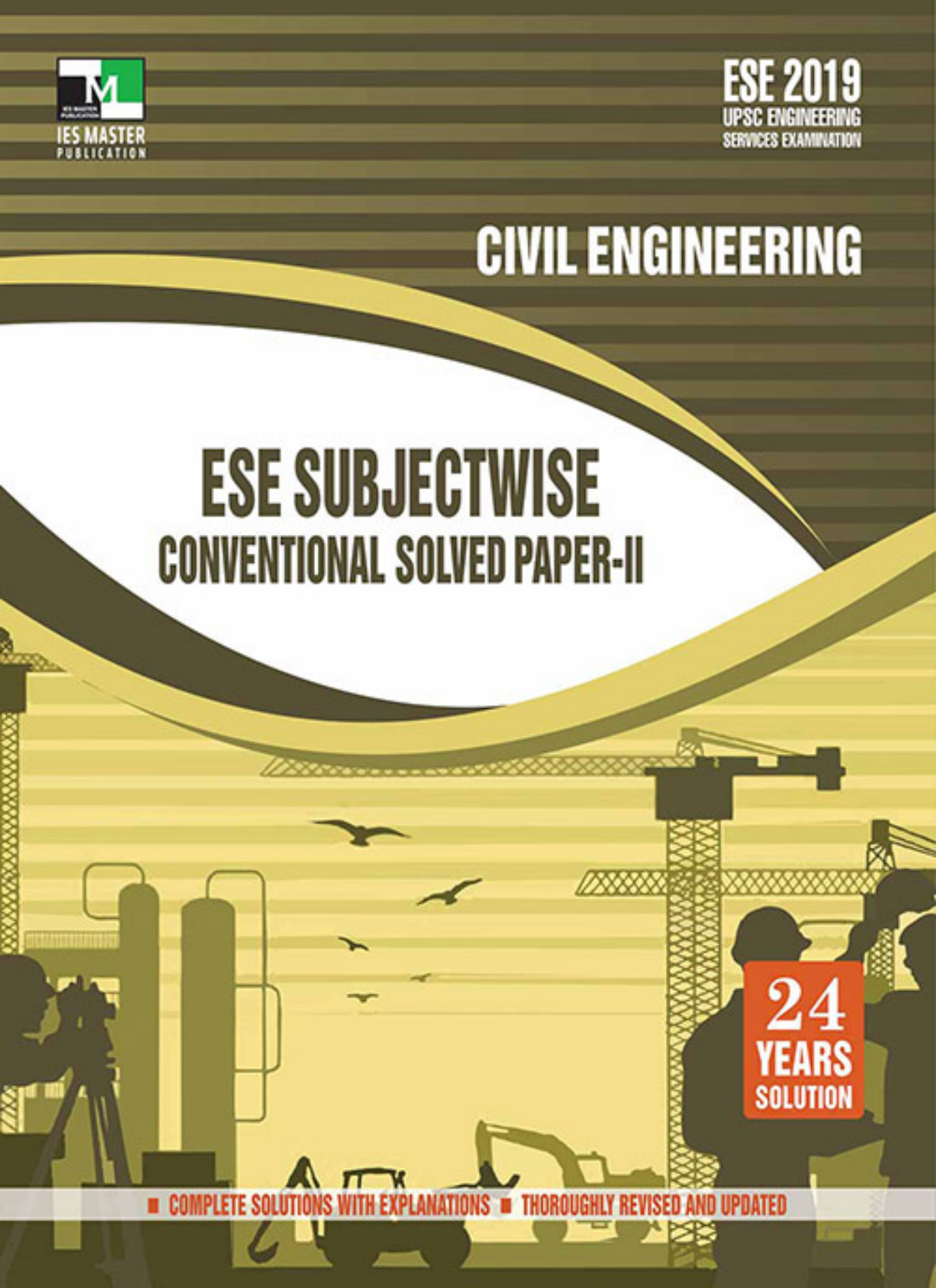
ESE 2019
UPSC ENGINEERING
SERVICES EXAMINATION

CIVIL ENGINEERING

ESE SUBJECTWISE
CONVENTIONAL SOLVED PAPER-II



24 YEARS SOLUTION

■ COMPLETE SOLUTIONS WITH EXPLANATIONS ■ THOROUGHLY REVISED AND UPDATED

CIVIL ENGINEERING

ESE SUBJECTWISE

CONVENTIONAL SOLVED PAPER-II

1995-2018

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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

CONTENTS

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UNIT 1

Environmental Engineering

SYLLABUS

(a) Water Supply Engineering:

Sources, Estimation, quality standards and testing of water and their treatment; Rural, Institutional and industrial water supply; Physical, chemical and biological characteristics and sources of water. Pollutants in water and its effects. Estimation of water demand; Drinking water Standards, Water Treatment Plants, Water distribution networks.

(b) Waste Water Engineering:

Planning & design of domestic waste water, sewage collection and disposal; Plumbing Systems. Components and layout of sewerage system; Planning & design of Domestic Waste-water disposal system; Sludge management including treatment; disposal and re-use of treated effluents; Industrial waste waters and Effluent Treatment Plants including institutional and industrial sewage management.

(c) Solid Waste Management:

Sources & classification of solid wastes along with planning & design of its management system; Disposal system, Beneficial aspects of wastes and Utilization by Civil Engineers.

(d) Air, Noise pollution and Ecology:

Concepts & general methodology.

IES – 1995

1. Determine the surface area of a settling tank for 0.5 m^3/sec design flow, using the design overflow rate as 32.5 m^3/day/m^2. Find the depth of the clarifier for the overflow rate and detention time of 95 mins. Assume, length-to-width ratios for settling tank between 2 : 1 and 5 : 1, and length not to exceed 100 m. Recommend the dimensions of the tank.

[20 Marks]

Sol. Data given:

$$\text{Discharge, } Q = 0.5 \text{ m}^3/\text{s} = 43{,}200 \text{ m}^3/\text{day}$$

$$\text{Overflow rate} = 32.5 \text{ m}^3/\text{day/m}^2$$

$$\text{Detention time, } t = 95 \text{ mins}$$

$$\text{Surface area of settling tank, } A = \frac{\text{Discharge}}{\text{Overflow Rate}} = \frac{43{,}200}{32.5} = 1329.231 \text{ m}^2$$

$$\text{Volume of tank, } V = Q \times t = 0.5 \times 95 \times 60 = 2850 \text{ m}^3$$

$$\text{Depth of clarifier, } H = \frac{V}{A} = \frac{2850}{1329.231} = 2.144 \text{ m}$$

Assume $\frac{L}{B} = 2$

$\therefore \quad L \times B = A = 1329.231$

$\Rightarrow \quad 2B^2 = 1329.231$

$\Rightarrow \quad B = 25.78 \text{ m} \;\&\; L = 51.56 \text{ m}$

Adopt, Length, $L = 52$ m

Width, $B = 26$ m

and by providing a freeboard of 0.3 m

Adopt depth of tank $= 2.144 + 0.3 = 2.444$ m

$= 2.5$ m

2. The treated domestic sewage of a town is to be discharged in a natural stream. Calculate the percentage purification required in the treatment plant with the following data ;

Population = 50, 000,

B.O.D. contribution per capita = 0.07 kg/day,

B.O.D. of stream on U/S Side = 3 mg/lit,

Permissible maximum B.O.D. of stream on D/S Side = 5 mg/lit,

Dry weather flow of sewage = 140 litters per capita per day,

Minimum flow of Stream = 0.13 m^3/sec.

Explain graphically the process of self purification of natural waters when sewage is discharged therein.

[15 Marks]

Sol.

$$\text{Population} = 50{,}000$$

$$\text{BOD contribution per capita} = 0.07 \text{ kg/day}$$

$$\text{Total BOD of raw sewage per day} = 0.07 \times 50{,}000 = 3500 \text{ kg/day}$$

$$\text{Sewage discharge, } Q_s = \frac{140 \times 50000}{86400} = 81.02 \text{ lit/sec.}$$

$$= 0.081 \text{ m}^3/\text{s}$$

$$\text{BOD of mix} = 5 \text{ mg/}l$$

$$\text{BOD of river, } C_R = 3 \text{ mg/l}$$

Let $\text{BOD of treated sewage} = C_S$

$$\therefore \quad \text{BOD of mix} = \frac{C_R Q_R + C_S Q_S}{Q_R + Q_S}$$

$$\Rightarrow \quad 5 = \frac{3 \times 0.13 + C_S \times 0.081}{0.13 + 0.081}$$

$$\Rightarrow \quad C_S = 8.211 \text{ mg/l}$$

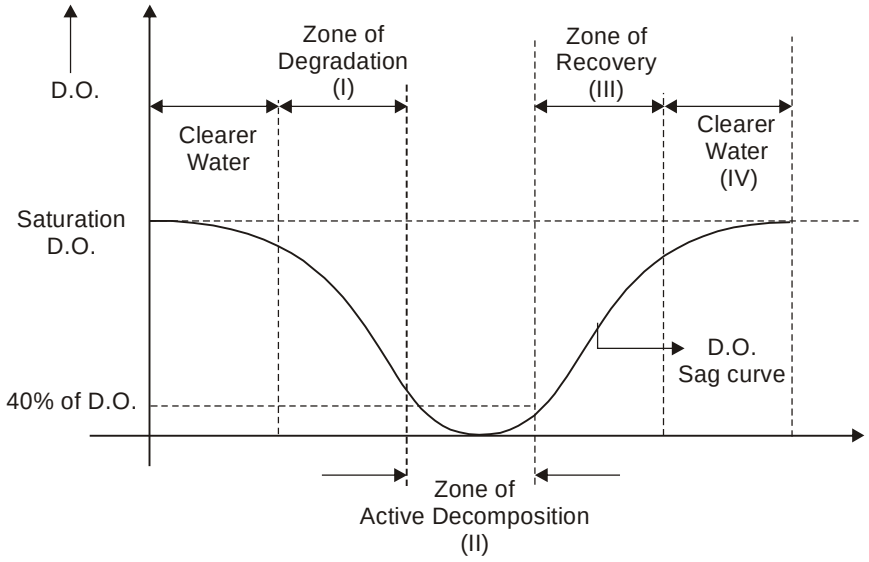
$$\text{BOD of untreated sewage} = \frac{3500 \times 10^6 \text{mg/d}}{50000 \times 140 \text{L/d}}$$

$$= 500 \text{ mg/L}$$

$$\text{Percentage purification required} = \frac{5.00 - 8.21}{500} \times 100$$

$$= 98.36 \%$$

Zones of pollution in River stream



The Process of self purification of natural waters can be divided into four zones which are described as follows :

Zone of Degradation

- It is found upto certain distance downstream of the point at which sewage is discharged into the river.
- In this algae dies but the fish survives.
- Water becomes dark and turbid.
- DO reduces to upto 40% of saturation.

Zone of Active Decomposition

- It is a zone of heavy pollution.
- Water becomes darker than zone of degradation.
- DO may even fall to zero.
- Fish will disappear.
- At upper ends, anaerobic bacteria will replace aerobic bacteria. Hence, anaerobic conditions set in and thus gases like CH_4, H_2S, CO_2 will be evolved and ugly scum forms on the surface.
- At the end of this zone DO concentration will reach upto 40% of the saturation DO.

Zone of Recovery

- BOD falls down.
- Organic matter will produce nitrate, sulphate, phosphate, carbonate, etc.
- D.O. content rises above 40% of the saturation value

Zone of Clear Water

- DO will rise upto its saturation value, but the pathogens may remain.

3. Consider the case where a noise level of 90 dBA exists for five minutes and is followed by a reduced noise level of 60 dBA for 50 mins. What is the equivalent continuous equal energy level (L_{eq}) for the 55-minute period? Assume a five-minute sampling period. Write the concepts of L_{eq}.

[15 Marks]

Sol. Equivalent continuous equal energy level,

$$L_{eq} = 10 \log \sum_{i=1}^{i=n} (10)^{L_i/10} \times t_i$$

where, n = total number of sound samples = 2

L_i = the noise level of any i^{th} level, L_1 = 90dB, L_2 = 60dB

t_i = time duration of i^{th} sample, expressed as fraction of total

sample time; $t_1 = \frac{5}{55}$; $t_2 = \frac{50}{55}$

$\therefore$ $$L_{eq} = 10 \times \log\left[(10)^{\frac{90}{10}} \times \frac{5}{55} + (10)^{\frac{60}{10}} \times \frac{50}{55}\right]$$

$$= 79.629 \text{ dBA}$$

The concept of L_{eq}

L_{eq} is defined as the constant noise level, which over a given time, expands the same amount of energy, as is expanded by the fluctuating levels over the same time.

L_{eq} noise levels are logarithmic (dB) values and cannot be added directly.

It is common practice to measure noise levels using the A - weighting setting built into all sound level meters. A - weighted measurements give higher weight to frequencies to which human ear is more sensitive and lesser weight to the ones to which human ear is less sensitive. This is doe to ensure that the meter is measuring pretty much what a human ear actually hears. Thus A - Weighted measurements are expressed as dBA or dB(A).

IES – 1996

4. A circular sewer of 45 cm diameter was designed for a town of population 30,000. The sewer was designed to carry 3.5 times of the dry weather flow. What slope should be provided to the sewer when running full? Value of n= 0.012 in Manning's equation. Assume other relevant data suitably.

[10 Marks]

Sol. Assuming water supply per capita = 135 *l*

$\therefore$ Total water supplied = 30000 × 135 = 4050000 lit/day

= 0.046875 m^3/s

Assuming that 80% of the water supplied to the town appears as sewage,

We have average discharge, Q = 0.8 × 0.046875

= 0.0375 m^3/s

At a peaking factor of 3.5,

Design discharge, Q_d = 3.5 × 0.0375 = 0.13125 m^3/s

Hydraulic radius under full flow, $R = \frac{A}{P} = \frac{\pi D^2/4}{\pi D} = \frac{D}{4}$

Area of flow, $A = \frac{\pi D^2}{4}$

Using Manning's equation, we know that

$$Q_d = \frac{1}{n} \times A \times R^{2/3} \times \sqrt{S}$$

$$\Rightarrow \quad 0.13125 = \frac{1}{0.012} \times \frac{\pi D^2}{4} \times \left(\frac{D}{4}\right)^{2/3} \times \sqrt{S}$$

$$\Rightarrow \quad 0.13125 = \frac{1}{0.012} \times \frac{\pi \times 0.45^2}{4} \times \left(\frac{0.45}{4}\right)^{2/3} \times \sqrt{S}$$

$$S = 1.806 \times 10^{-3}$$

or S = 1 in 553.78

5. In a continuous flow settling tank, 3.5 m deep and 65 m long, if the flow velocity of water observed is 1.22 cm/s. what size of the particles of specific gravity 2.65 may be effectively removed? Assume temperature 25°C and kinematic viscosity of water as 0.01 cm^2/s.

[10 Marks]

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