

CIVIL ENGINEERING

for
UPSC Engineering Services Examination
and
State Engineering Service Examination

CONVENTIONAL QUESTION PRACTICE BOOK
FOR ESE MAINS EXAMINATION



IES MASTER PUBLICATION

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

Mob.: 81 3090 9220, 97 1185 3908 **Ph.:** 011 2652 2064

E-mail : info.publications@iesmaster.org, info@iesmaster.org

Web : iesmasterpublications.com, iesmaster.org



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E-mail : info.publications@iesmaster.org

Web : iesmasterpublications.com

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PREFACE

The 'Conventional Question Practice Book for Civil Engineering' has been written to cater to the needs of students appearing for ESE Mains. It is in fact the performance of the candidates in this Mains exam that determines the final outcome. The main objective of this book is to help students prepare for the conventional questions and score better.

The conventional questions asked in ESE Mains are of two types – Descriptive Theory Type and Problems Based on Formulas. Scoring well at this stage depends not only on a candidate's technical understanding but also on the presentation of answers in a manner best appreciated by the UPSC.

To take on the ESE Mains challenge, a candidate should have good writing skills, which demands a lot of practice, and an eye for detail. In addition to it, question selection ability also plays a vital role. Keeping these things in perspectives, IES Master has compiled this book to equip civil engineering students with the necessary facets of answer writing in ESE Mains.

To help students push their threshold further, the book includes self sufficient practice questions with detailed solution from each and every concept. Having practiced this book thoroughly, the candidates can crystal gaze the ESE challenge from UPSC perspective.

Follow this book diligently, and experience what goes in transforming a good score into a great score.

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SYLLABUS

PAPER – I

- 1. Building Materials:** Stone, Lime, Glass, Plastics, Steel, FRP, Ceramics, Aluminum, Fly Ash, Basic Admixtures, Timber, Bricks and Aggregates: Classification, properties and selection criteria;
Cement: Types, Composition, Properties, Uses, Specifications and various Tests; Lime & Cement Mortars and Concrete: Properties and various Tests; Design of Concrete Mixes: Proportioning of aggregates and methods of mix design.
- 2. Solid Mechanics:** Elastic constants, Stress, plane stress, Strains, plane strain, Mohr's circle of stress and strain, Elastic theories of failure, Principal Stresses, Bending, Shear and Torsion.
- 3. Structural Analysis:** Basics of strength of materials, Types of stresses and strains, Bending moments and shear force, concept of bending and shear stresses; Analysis of determinate and indeterminate structures; Trusses, beams, plane frames; Rolling loads, Influence Lines, Unit load method & other methods; Free and Forced vibrations of single degree and multi degree freedom system; Suspended Cables; Concepts and use of Computer Aided Design.
- 4. Design of Steel Structures:** Principles of Working Stress methods, Design of tension and compression members, Design of beams and beam column connections, built-up sections, Girders, Industrial roofs, Principles of Ultimate load design.
- 5. Design of Concrete and Masonry structures:** Limit state design for bending, shear, axial compression and combined forces; Design of beams, Slabs, Lintels, Foundations, Retaining walls, Tanks, Staircases; Principles of pre-stressed concrete design including materials and methods; Earthquake resistant design of structures; Design of Masonry Structure.
- 6. Construction Practice, Planning and Management:** Construction - Planning, Equipment, Site investigation and Management including Estimation with latest project management tools and network analysis for different Types of works; Analysis of Rates of various types of works; Tendering Process and Contract Management, Quality Control, Productivity, Operation Cost; Land acquisition; Labour safety and welfare.

PAPER – II

- 1. Flow of Fluids, Hydraulic Machines and Hydro Power:**
 - (a) Fluid Mechanics, Open Channel Flow, Pipe Flow:** Fluid properties; Dimensional Analysis and Modeling; Fluid dynamics including flow kinematics and measurements; Flow net; Viscosity, Boundary layer and control, Drag, Lift, Principles in open channel flow, Flow controls. Hydraulic jump; Surges; Pipe networks.
 - (b) Hydraulic Machines and Hydro power:** Various pumps, Air vessels, Hydraulic turbines – types, classifications & performance parameters; Power house – classification and layout, storage, pondage, control of supply.
- 2. Hydrology and Water Resources Engineering:** Hydrological cycle, Ground water hydrology, Well hydrology and related data analysis; Streams and their gauging; River morphology; Flood, drought and their management; Capacity of Reservoirs.

Water Resources Engineering: Multipurpose uses of Water, River basins and their potential; Irrigation systems, water demand assessment; Resources - storages and their yields; Water logging, canal and drainage design, Gravity dams, falls, weirs, Energy dissipaters, barrage Distribution works, Cross drainage works and head-works and their design; Concepts in canal design, construction & maintenance; River training, measurement and analysis of rainfall.

3. Environmental Engineering:

(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.

4. Geo-technical Engineering and Foundation Engineering:

(a) **Geo-technical Engineering:** Soil exploration - planning & methods, Properties of soil, classification, various tests and interrelationships; Permeability & Seepage, Compressibility, consolidation and Shearing resistance, Earth pressure theories and stress distribution in soil; Properties and uses of geo-synthetics.

(b) **Foundation Engineering:** Types of foundations & selection criteria, bearing capacity, settlement analysis, design and testing of shallow & deep foundations; Slope stability analysis, Earthen embankments, Dams and Earth retaining structures: types, analysis and design, Principles of ground modifications.

5. Surveying and Geology:

(a) **Surveying:** Classification of surveys, various methodologies, instruments & analysis of measurement of distances, elevation and directions; Field astronomy, Global Positioning System; Map preparation; Photogrammetry; Remote sensing concepts; Survey Layout for culverts, canals, bridges, road/railway alignment and buildings, Setting out of Curves.

(b) **Geology:** Basic knowledge of Engineering geology & its application in projects.

6. Transportation Engineering:

Highways: Planning & construction methodology, Alignment and geometric design; Traffic Surveys and Controls; Principles of Flexible and Rigid pavements design.

Tunneling: Alignment, methods of construction, disposal of muck, drainage, lighting and ventilation.

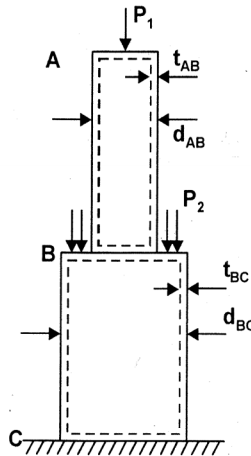
Railways Systems: Terminology, Planning, designs and maintenance practices; track modernization.

Harbours: Terminology, layouts and planning.

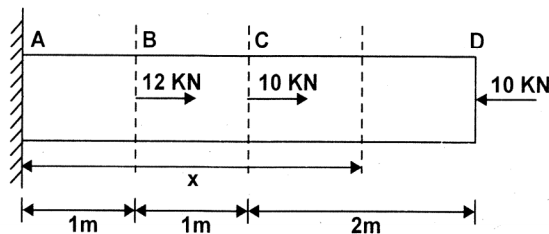
Airports: Layout, planning & design.

STRENGTH OF MATERIALS

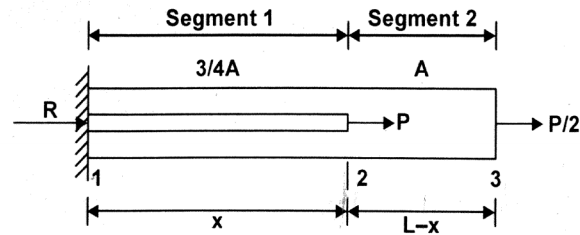
1. A hollow circular post ABC (See Figure) supports a load $P_1 = 7.5 \text{ KN}$ acting at the top A. A second load P_2 is uniformly distributed around the cap plate at B. The diameter and thickness of the upper and lower parts of the post are $d_{AB} = 32 \text{ mm}$, $t_{AB} = 12 \text{ mm}$, $d_{BC} = 57 \text{ mm}$ and $t_{BC} = 9 \text{ mm}$ respectively.
- Calculate the normal stress σ_{AB} in the upper part of post?
 - If it is desired that the lower part of the post have the same compressive stress as the upper part, what should be the magnitude of the load P_2 ?
 - If P_1 remains at 7.5 KN and P_2 is now set at 10 KN , what new thickness of BC will result in the same compressive stress in both parts ?



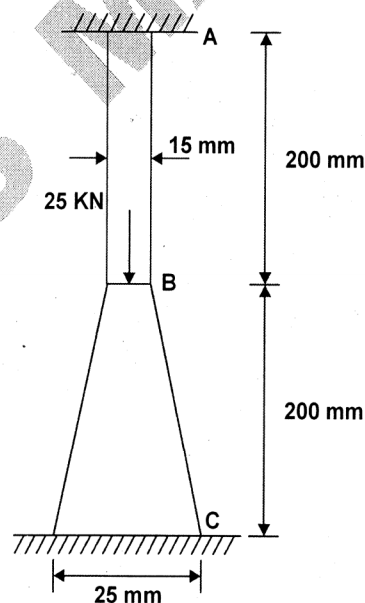
2. A steel rod having diameter of 40 mm is loaded as shown in figure. Assume $E = 200 \text{ KN/mm}^2$. Determine the deformation of the free end. Also evaluate the distance x from the left end support to a point at which the deformation is zero.



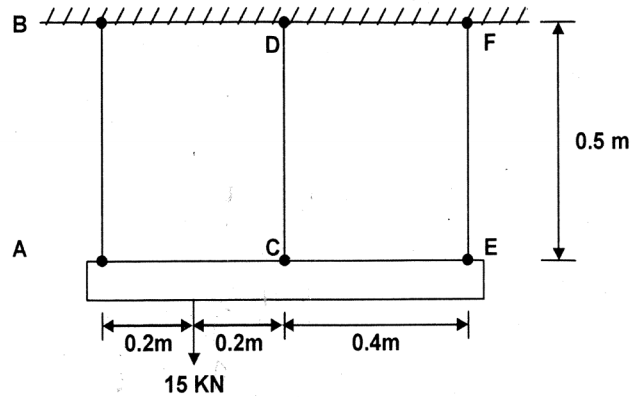
3. The non-prismatic cantilever circular bar shown has an internal cylindrical hole from distance 0 to x , so that the net area of the cross-section for segment 1 is $3A/4$. Load P is applied at x , and load $P/2$ is applied at end as shown in fig.



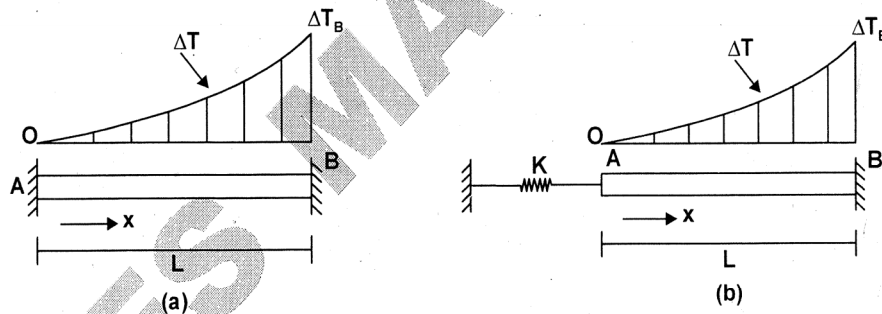
- (a) Find reaction R
 - (b) Find internal axial forces N_1 in segments 1 and 2
 - (c) Find x required to obtain axial displacement of at joint 3 of $\Delta_3 = PL/AE$
 - (d) In (c), what is displacement joint 2, Δ_2 ?
 - (e) If P acts at $x = 2L/3$ and $P/2$ at joint 3 is replaced by βP , find β so that $\Delta_3 = PL/AE$
4. A prismatic circular bar of length L and cross-sectional area A is rotating in a horizontal plane about the vertical axis passing through one end. If the density of bar is ρ , and bar is rotating at constant angular velocity ω rad/sec. then what is the elongation of bar on account of centrifugal action. Also draw the axial stress diagram.
 5. The steel column (shown in figure) of circular cross-section is attached to rigid supports at A and C . Find the maximum stress in the column caused by the 25 kN load.



6. The three steel bars AB , CD and EF as shown in the given figure are pin connected to a rigid member. If the applied load on the member is 15 kN, determine the force developed in each bar. Bars AB and EF each have a cross-sectional area of 50 mm^2 and bar CD has a cross-sectional area of 30 mm^2 .

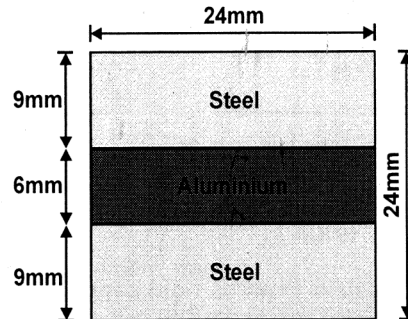


7. A bar AB of length L is held between rigid supports and heated nonuniformly in such a manner that the temperature increases ΔT at distance x from end A is given by the expression $\Delta T = \Delta T_B \frac{x^3}{L^3}$, where ΔT_B is the increase in temperature at end B of the bar (see in the figures).
- Derive a formula for the compressive stress σ_C in the bar. (Assume that the material has modulus of elasticity E and coefficient of thermal expansion α).
 - Now modify the formula in (a) if the rigid support at A is replaced by an elastic support at A having a spring constant K (see figure b). Assume that only bar AB is subjected to the temperature change. Assume CSA of bar is A through out.



8. A circular aluminium bar of diameter $d_0 = 25$ mm and length, $L_0 = 250$ mm, gets elongated by 1.20 mm due to the application of 165 kN force. Determine the modulus of elasticity. Also find the contraction in diameter.
Take $G_{Al} = 26$ GPa, $(\sigma_y)_{Al} = 440$ MPa
9. A bar of steel is 40 mm \times 40 mm in section and is 120 mm long. It is subjected to a tensile load of 250 kN along the longitudinal axis and tensile loads of 600 kN and 400 kN on the lateral faces.
- Find the change in the dimension of the bar and the change in volume.
 - Find also what axial longitudinal tensile load acting alone can produce the same longitudinal strain as in (i)
- Take $E = 2 \times 10^5$ N/mm² and $1/m = 0.3$.
10. A flat bar of aluminium alloy 24 mm wide and 6 mm thick is placed between two steel

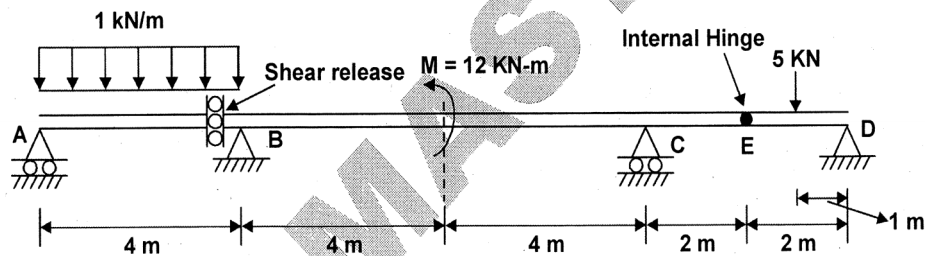
bars each 24 mm wide and 9 mm thick to form a composite bar 24 mm × 24 mm as shown in figure. The three bars are fastened together at their ends when the temperature is 10°C. Find the stress in each of the material when the temperature of the whole assembly is raised to 50°C.



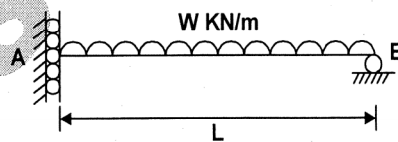
If at the new temperature a compressive load of 20 kN is applied to the composite bar what are the final stresses in steel and aluminium? Take $E_s = 2 \times 10^5 \text{ N/mm}^2$,

$$E_{al} = \frac{2}{3} \times 10^5 \text{ N/mm}^2, \quad \alpha_s = 1.2 \times 10^{-5} \text{ per } ^\circ\text{C} \text{ and } \alpha_{al} = 2.4 \times 10^{-5} \text{ per } ^\circ\text{C}.$$

11. A beam ABCD is shown below. For the given loading. Draw B.M.D. and S.F.D.



12. Draw the bending moment and shear force diagram for the given beam.



13. A beam ABCD is hinged at A and simply supported at D. A vertical strut CE (weight less) is 2.5 m long fixed at C. A frictionless pulley is attached at E. A flexible string carries load of 8 kN and passes over the pulley and attached to Beam at D as shown in figure. Draw axial force, shear force and bending moment diagram for beam ABCD.

