

# **UPSC Mains Civil Engineering Optional Paper-I Syllabus**

## **1. Engineering Mechanics, Strength of Materials and Structural Analysis.**

### **1.1 Engineering Mechanics:**

Units and Dimensions, SI Units, Vectors, Concept of Force, Concept of particle and rigid body. Concurrent, Non-Concurrent and parallel forces in a plane, moment of force free body diagram, conditions of equilibrium, Principle of virtual work, equivalent force system.

First and Second Moment of area, Mass moment of Inertia.

Static Friction.

### **Kinematics and Kinetics:**

Kinematics in cartesian coordinates, motion under uniform and non-uniform acceleration, motion under gravity. Kinetics of particle: Momentum and Energy principles, collision of elastic bodies, rotation of rigid bodies.

### **1.2 Strength of Materials:**

Simple Stress and Strain, Elastic constants, axially loaded compression members, Shear force and bending moment, theory of simple bending, Shear Stress distribution across cross sections, Beams of uniform strength.

Deflection of beams: Mecauly's method, Mohr's Moment area method, Conjugate beam method, unit load method. Torsion of Shafts, Elastic stability of columns, Euler's, Rankine's and Secant formulae.

### **1.3 Structural Analysis:**

Castigliano's theorems I and II, unit load method, of consistent deformation applied to beams and pin jointed trusses. Slope-deflection, moment distribution.

Rolling loads and Influences lines: Influences lines for Shear Force and Bending moment at a section of a beam. Criteria for maximum shear force and bending Moment in beams traversed by a system of moving loads. Influences lines for simply supported plane pin jointed trusses.

Arches: Three-hinged, two hinged and fixed arches, rib shortening and temperature effects.

Matrix methods of analysis: Force method and displacement method of analysis of indeterminate beams and rigid frames.

Plastic Analysis of beams and frames: Theory of plastic bending, plastic analysis, statical method, Mechanism method.

Unsymmetrical bending: Moment of inertia, product of inertia, position of Neutral Axis and Principal axes, calculation of bending stresses.

## **2. Design of Structures: Steel, Concrete and Masonry Structures.**

### **2.1 Structural Steel Design:**

Structural steel: Factors of safety and load factors. Riveted, bolted and welded joints and connections. Design of tension and compression members, beams of built up section, riveted and welded plate girders, gantry girders, stanchions with battens and lacing.

### **2.2 Design of Concrete and Masonry Structures:**

Concept of mix design. Reinforced Concrete: Working Stress and Limit State method of design—Recommendations of I. S. codes. Design of one way and two way slabs, stair-case slabs, simple and continuous beams of rectangular, T and L sections. Compression members under direct load with or without eccentricity.

Cantilever and Counter fort type retaining walls.

Water tanks: Design requirements for Rectangular and circular tanks resting on ground.

Prestressed Concrete: Methods and systems of prestressing, anchorages, Analysis and design of sections for flexure based on working stress, loss of prestress.

Design of brick masonry as per I. S. Codes



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## **3. Fluid Mechanics, Open Channel Flow and Hydraulic Machines:**

### **3.1 Fluid Mechanics:**

Fluid properties and their role in fluid motion, fluid statics including forces acting on plane and curve surfaces.

Kinematics and Dynamics of Fluid flow: Velocity and accelerations, stream lines, equation of continuity, irrotational and rotational flow, velocity potential and stream functions.

Continuity, momentum, energy equation, Navier Stokes equation, Euler's equation of motion, application to fluid flow problems, pipe flow, sluice gates, weirs.

### **3.2 Dimensional Analysis and Similitude:**

Buckingham's Pi-theorem, dimensionless parameters.

### **3.3 Laminar Flow:**

Laminar flow between parallel, stationary and moving plates, flow through tube.

### **3.4 Boundary layer:**

Laminar and turbulent boundary layer on a flat plate, laminar sub-layer, smooth and rough boundaries, drag and lift.

Turbulent flow through pipes: Characteristics of turbulent flow, velocity distribution and variation of pipe friction factor, hydraulic grade line and total energy line.

### **3.5 Open Channel Flow:**

Uniform and non-uniform flows, momentum and energy correction factors, specific energy and specific force, critical depth, rapidly varied flow, hydraulic jump, gradually varied flow, classification of surface profiles, control section, step method of integration of varied flow equation.

### **3.6 Hydraulic Machines and Hydropower:**

Hydraulic turbines, types classification, Choice of turbines performance parameters, controls, characteristics, specific speed.

Principles of hydropower development.

## **4. Geotechnical Engineering:**

Soil Type and Structure-gradation and particle size distribution-consistency limits.

Water in soil-capillary and structural-effective stress and pore water pressure-permeability concept-filed and laboratory determination of permeability-Seepage pressure-quick sand conditions Shear strength determination— Mohr Coulomb concept.

Compaction of soil-Laboratory and filed test. Compressibility and consolidation concept- consolidation theory-consolidation settlement analysis.

Earth pressure theory and analysis for retaining walls, Application for sheet piles and Braced excavation.

Bearing capacity of soil-approaches for analysis- Filed tests-settlement analysis- stability of slope of earth walk.

Subsurface exploration of soils-methods

Foundation-Type and selection criteria for foundation of structures-Design criteria for foundation Analysis of distribution of stress for footings and pile-pile group action-pile load test.

Ground improvement techniques.