

Civil Engineering Department

Syllabus for PhD Comprehensive Examination

1. Environmental Engineering

Environmental Chemistry and Microbiology

Basic Principles, stoichiometric calculations. Acid-Base equilibria, carbonate system in water, buffering in water system, titration curve. Solubility in water. Analysis and importance of common water/wastewater quality parameters

Microorganisms - classification, prokaryotic and eukaryotic cells, structure, characteristics, metabolism of microorganisms: Environmental factors, nutrition and metabolism, growth phases, Microbiology of drinking water: Distribution of microorganisms, indicator organisms, MPN index, M.F. technique, standards. Microbiology of wastewater treatment. **(20%)**

Water Treatment

Important water treatment processes: Principles, working, design and maintenance of Sedimentation, Coagulation, filtration, Adsorption, gas transfer, chemical precipitation, water softening and disinfection processes. Household water treatment, Removal of specific pollutants such as arsenic, fluoride, iron, and nitrate **(20%)**

Wastewater Treatment

Principles, working, design and maintenance of the following wastewater treatment processes: aerobic/anaerobic, attached/suspended, activated sludge, tricking filter, SBR. Anaerobic processes – microbiology, process, design, Sludge treatment. Natural treatment processes. Tertiary treatment of wastewater and wastewater reuse **(20%)**

Air and Noise Pollution

Air quality and standards, emission standards, important air pollutants - carbon monoxide, nitrogen dioxide, photochemical smog, ozone, particulate pollutants, oxides of sulphur, lead, hydrocarbon – their sources, effects. Application of Gaussian Plume model.

Control of suspended particulate matter, design criteria of settling chambers, cyclones, bag filters, scrubbers and electrostatic precipitators, control of gaseous pollutants.

Noise Pollution: Fundamentals and terminologies, health impacts, mitigation / control measures.

(20%)

Solid Waste Management

Generation and composition of MSW, Characterisation of MSW. Materials recovery and treatment – composting, Concepts of waste-to-energy methods, Energy recovery - Incinerators. Landfills: Site selection, design and operation, drainage and leachate collection systems. **(20%)**

References

1. Metcalf & Eddy, "Waste water engineering: treatment and reuse", 4th edition, McGraw Hill Education, 2017.
2. Sawyer, McCarty and Parkin, "Chemistry for environmental engineering and science", 5th edition, McGraw Hill Education, 2017.
3. Masters and Ella, "Introduction to environmental engineering and science", 3rd edition, Pearson Education, 2015.

4. Peavy, Rowe and Tchobanoglous, "Introduction to environmental engineering ", 6th edition, McGraw Hill Education, 2016.
5. Tchobanoglous, "Integrated solid waste management: Engineering principles and management issues", McGraw Hill Education, 2014.
6. Rao and Rao, "Air pollution", 5th edition, McGraw Hill Education, 2017.

2. Construction Technology and Management

Construction Project Planning and Control

Importance of sound planning, Scheduling, principles and techniques, Scheduling methods (AOA & AON), critical path method, concept of float, project evaluation and review techniques, line of balance variances in project duration and cost, network scheduling with limited resources, resource allocation, smoothing and leveling, updating the network, master networks, the time -cost trade-off approach, progress review and reporting, risk of schedule delays, missing milestone deliverables and its impact (from client and contractors view point) change management, contemporaneous records, documenting delays and maintaining records.

Parameters of project performance, time, cost and quality and their interrelationships, schedule and cost control tools and techniques, performance reporting, audit, corrective and preventive actions, fund flow control, management information system and application of management software. **(20%)**

Construction Methods & Equipment

Form work design and scaffolding, slip form and other moving forms, Shoring, Reshoring, and Back shoring in multistoried Building construction.

High rise construction, Bridge construction including segmental construction, incremental construction and push launching techniques, Box pushing method, Top to bottom Construction. Factors affecting selection of equipment - technical and economic, Analysis of production outputs and costs, Characteristics and performances of equipment for major civil engineering activities such as Earth moving, erection, material transport, pile driving, Dewatering, and Concreting, Ready mix concrete plants. **(20%)**

Advanced Construction Materials

Environmental Influences, Thermal effects Effect of Chemicals, Fire resistance, Corrosion and Oxidation, Radiation. Properties of fresh & hardened concrete. Shrinkage & creep of concrete. Introduction, sustainability and goals, current situation, earth's natural system, carbon cycle, role of construction materials, CO₂ from fossil fuel vis-à-vis cement and other construction materials. Construction material and indoor air quality. Energy for production, transportation and erection, Estimation methodology, Computation of embodied energy for building. Primary energy and Energy Concepts. Polymer materials, Thermo - Plastic, Polymer Concrete, Composite, materials, Ferro cement, Ferroconcrete, Building materials from Agricultural,& Industrial wastes, M Sand, Glass, Cladding, Light Weight Concrete. **(15%)**

Project Appraisal and Finance

NPV, BCR, IRR, ARR, urgency-payback period, assessment of various methods, Indian practice of investment appraisal, international practice of appraisal, analysis of risk, different methods for selection of a project and risk analysis in practice, ownership structures; BOT, BOLT, BOOT models.

Policy for working capital, estimating working capital need, inventory management, account receivable, credit and cash management, managing payments to supplies and outstanding, capital investment decisions, techniques of capital budgeting, cost of capital. Cash flow analysis **(15%)**

Construction Contract and Law

Concept of contract, types of contracts, joint venture, merging, acquisition, features and suitability, design of contract documents, international contract document, standard contract document, law of torts, Indian contract act 1872, Introduction to various standard forms of contract such as FIDIC, JCT and NEC. Prequalification and Bidding process, potential contractual problems, Rules of interpretation of contract clauses, Concession agreements.

Sources of claims and disputes, construction claims procedure, methods of dispute resolution, alternative dispute resolution method, comparison of actions and laws, agreements, subject matter, violations, Arbitration and Conciliation act 1996 and recent amendments in 2015, Delay analysis, case studies, professional ethics, duties and responsibilities of parties. **(15%)**

Construction Quality and Safety

Road Map for TQM Implementation, Role of management in TQM, Quality improvement planning measurement, construction site implementation, six sigma in quality management.

Safety and accidents in construction projects, theories of accident causation, health and illness related with construction works, cost of construction injuries, safety risk analysis and control, personal protective equipment, occupational and safety hazard assessment, legal implications, OSH Management System.

Problem areas in construction safety, elements of an effective safety programme, job site safety assessment, safety meetings, and safety incentives Safety in construction contracts, substance abuse, safety record keeping. **(15%)**

References

1. Harris, F, McCaffer, R and Edum-Fotwe, F (2006) Modern Construction Management, sixth edition, Blackwell Publishers.
2. Jha K N (2012) Formwork for Concrete Structures, Tata McGraw Hill, New Delhi.
3. Jha, K N (2015) Construction Project Management: Theory and Practice, Second Edition, Pearson Publishers, New Delhi.
4. Jimmie W Hinze (2013) Construction Contracts, 3rd Edition. McGraw Hill.
5. Levitt, R E and Samelson, Nancy Morse (1993) Construction Safety Management 2nd Edition, Wiley Publisher.
6. Prasanna Chandra (1995) Projects Preparation, Appraisals, Budgeting and Implementation, 3rd Edition, Tata Mc Graw Hill Publishing Co. Ltd.
7. Taylor, G A (1968) Managerial and Engineering Economy. East-West Edition.
8. Van Horne, J C (1990). Fundamentals of Financial Management, Printice-Hall of India Ltd.
9. Wu Chung, H (2006) Advanced Civil Infrastructure Materials, First Edition, Woodhead Publishing Limited.

3. Transportation Engineering and Planning

Materials and Pavements

Soil – Soil classification and its systems, Manual identification tests, desirable properties of soil for road construction, Importance of soil subgrade, problems in soil subgrade, sub-soil drainage, soil stabilization, Strength properties of soils.

Road Aggregates –Origin, Physical, mechanical and durability properties of aggregates, desirable properties of aggregates for road construction.

Bitumen –Bitumen sources and manufacturing, bitumen constituents, structure and rheology, types of bituminous binders, their properties, tests and specifications

Pavement Structure: Components of pavement structure, functions of subgrade, subbase, base course, binder course and wearing course; specifications for construction of different layers of pavement, quality control during road construction.

Bituminous Mixes – Desirable properties of bituminous mixes for bound & unbound base courses and wearing course in accordance with MoRTH specifications, Design of bituminous mixes by Marshall and Superpave methods, fillers. Recent properties in Cold mix, Warm mix and Hot mix asphalt, Durability properties of bituminous mixes.

Flexible Pavements – Design approach, Elastic layer theory, Stresses in flexible pavements, Design of pavement as per IRC 37-2018, Reclaimed asphalt pavement design, Distresses, Evaluation and strengthening of pavements.

Rigid pavements – Components of rigid pavements, types of joints, dowel and tie bars and their design, wheel load stresses, temperature stress, warping stress, design of rigid pavements based on IRC: 58 2015, Dry lean concrete, PQC, Concrete block pavements, Types of cement, physical and mechanical properties of cement, Factors affecting concrete mix design, Design of concrete mixes, Distresses, Evaluation and strengthening of pavements.

Traffic Engineering and Management

Traffic Engineering: Elements of traffic engineering, traffic stream characteristics, Traffic studies on flow, speed, travel time - delay and O-D study, PCU, peak hour factor, parking study, accident study and analysis, black spot identification, statistical analysis of traffic data; Microscopic and macroscopic parameters of traffic flow, fundamental relationships; Traffic regulations and control systems, signal design by Webster's method; Types of intersections and channelization; Highway capacity and level of service of rural highways and urban roads, Intelligent Transportation systems.

Traffic Flow Theory: Measurement of microscopic and macroscopic traffic flow characteristics; Time-space plots, gap acceptance behaviour, Shock Wave Theory, Car-Following Theory, Advanced Car-Following Models, Psycho-physical models, Traffic Flow Stability, Social-force models, Hysteresis based behavioral studies, Shock wave equations; Types of shockwaves and propagation; Shock waves at toll gates, Signalized intersections, Shockwaves due to incidents; Shockwaves due to bottlenecks, Shockwave analysis on flow-density diagram and using simulation, queuing theory.

Geometric Design: Highway alignment and engineering surveys; Geometric design of highways - cross-sectional elements, sight distances, horizontal and vertical alignments

Transportation Planning

Urban Transportation Planning: Urban growth mechanism – Urban morphology- Urbanisation & travel demand, Urban travel patterns - Study area delineation- Zoning - Planning surveys - Urban activity system- Sustainable urban transport - Systems approach; Travel demand estimation, data need and sources, survey methodology, trip generation, trip distribution, mode choice, route assignment, random utility models; Urban system components - Urban spatial structure – Accessibility - Location theory - Land use models - Land use transport models, Lowry & Garin – Lowry models; sustainable transportation – Walk, Bicycle and Public Transport, type and characteristics of urban mass transit systems

Public Transport Planning: Operational characteristics speed, capacity & payloads – Route capacity – Comfort conditions - Performance relationships - Public and Private Operations - Modes for Intercity Transport; Data requirements & Collection techniques, Conventional Methods - Destination Survey - Transit Stop & Ride Surveys and Analysis - Mode Split Models - Captive and Choice Riders - Attitudes of Travellers - Patronage Determination; Frequency & headway determination methods – Rail operation design – Bus operation design – Way capacity & Station capacity – Transit level of service; Performance Evaluation – Efficiency, Capacity, Productivity and Utilisation – Performance Evaluation Techniques and Application – System Network Performance – Transit Terminal Planning and Design

Transportation Economics

Generation and screening of project alternatives - Different methods of economic analysis: - Discounting and Non discounting criteria methods – NPV - IRR, Benefit/Cost analysis. Feasibility and evaluation, cost, impacts and performance levels, evaluation of alternatives, analysis techniques, cost benefit analysis, social and financial benefits, Internal Rate of return method for economic and financial viability, valuation of time

References

1. IRC: SP: 30-1993., Manual on Economic Evaluation of Highway Projects in India.
2. Sarkar P K., Maitri V. Economics in Highway and Transportation Planning, Standard Publisher, New Delhi, 2010.
3. Kothari, C.R., Research Methodology: Method and Techniques, New Age International Publication, 2018
4. Richard Johnson, Probability and Statistics for Engineers, PHI Publication 2018.
5. Drew, D.R., Traffic Flow Theory & Control, McGraw Hill, New York, 1968.
6. Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi, 2002.
7. Khisty C J, Lall B. Kent; Transportation Engineering-An Introduction, Prentice-Hall,NJ, 2005
8. May, A.D., Traffic Flow Fundamentals, Prentice – Hall, Inc., New Jersey, 1990.
9. Prithvi Singh Kandhal, Bituminous Road Construction in India, PHI Learning Private Limited, 2016.
10. Rajib B. Mallick and Tahar El-Korchi, Pavement Engineering - Principles and Practices, Second Edition, CRC Press, 2013
11. Relevant IRC and IS Codes.
12. Hutchinson B.G., Principles of Urban Transportation System Planning, Mc-Graw Hill, 1974.
13. Chakroborty P., Das N., Principles of Transportation Engineering, PHI,New Delhi,2003
14. Sarkar P., Maitry V., Joshi G.J., Transportation Planning –Principles, Practices & Policies, PHI,New Delhi (2014).
15. Papacostas C.S. and Prevedouros, P.D., Transportation Engineering & Planning, PHI, New Delhi,2002.

4. Urban Planning

Urban Planning Fundamentals

Growth Patterns: City Changes with time and growth, Growth theory, land use, Modern Urban forms
Planning Survey: Objectives, types, significance, methodology, analysis and application (15%)

Housing

Planning for Residential area: Building Bye Laws (GCDCR), Housing and neighborhood planning, Layout planning
Housing for Urban Poor: Slum Scheme, rehabilitation, in-situ upgradation (10%)

Traffic and Transportation Planning

Traffic Characteristics: Policies, traffic studies and problems
Traffic Planning and Management: Design Town Center and CBD Area, and management technique (15%)

Sustainable Urban Planning Practices

Urban Land Management: Models, issues, Planners Role, URDPFI and TCPO guidelines
Town Planning Scheme and Development Plan: Guidelines and processes (15%)

Urban Infrastructure Planning

Network and Services: Core Municipal Infrastructure Components and Significance, Technology, Cost recovery
Water Supply and Sewerage network: Norms and Standards (15%)

Project Formulation and Appraisal

Project Formulation: Preliminary analysis, Feasibility report and clearance requirements
Project Appraisal: Methods, Investment appraisal, Analysis of Risk, BOT, BOLT and BOOT Models (10%)

Urban Governance and Legislation

Indian system of Urban Government: Salient features of local government system, constitution Amendment Act
Urban Local Governance participatory processes: Role of Municipal bodies, Urban Development Authority - Function, Power and Organization (10%)

Regional Planning

Regional Analysis: Introduction, Linear Programming, Analysis
Growth Models: Concept, Central Place Theory (10%)

References

- 1) A.B. Gillion and Simon Eisner, "The Urban Pattern", CBS Publishers and Distributors, Delhi.
- 2) R. Ramachandran, "Urbanisation and Urban Systems in India", Oxford Publications.
- 3) D.J. Dwyer, "People & Housing in 3rd. World Cities", Longman, London.
- 4) Kadiali, L.R., "Traffic and Transportation Planning", Khanna Publishers, Delhi.
- 5) MARGARET ROBERTS, "Town Planning Techniques", Hutchinson Educational Publication
- 6) N. V. MODAK AND V. N. AMBEDKAR, "Town and Country Planning and Housing", Orient Longman Limited.
- 7) FAIR, G. M., GAYER, J.C. AND OKUN, D.A., "Elements of water supply and Waste water Disposal" John Willey & Sons, New York.
- 8) T.M. VINODKUMAR, "Networks and services", ITPI Reading Manuals.
- 9) Prasanna Chandra, (1995) "Project Preparation, Appraisals, Budgeting and Implementation", Tata Mc Graw Hill Publishing Co., Ltd., New Delhi
- 10) Joy. P. K. (2007) "Total Project Management-The Indian Context (Chapters 3-+7)", New Delhi, Macmillan India Ltd.
- 11) INSARD WALTER, "Methods of Regional Analysis – An Introduction to Regional Science", MIT Press, Cambridge, 1960.

5. Water Resources Engineering

Equal weightage for the five sections

1. Fluid Mechanics

FLUID STATICS -Fluid pressure at a point and its measurements, manometry, hydrostatic forces on plane and curved surfaces, buoyancy and floatation, relative equilibrium under linear acceleration and constant rotation.

FLUID KINEMATICS - velocity field, classification of fluid flows based on space & time, one-, two- and three- dimensional flows. Eulerian and Lagrangian approaches, stream lines, path lines and streak lines, stream tubes, continuity equation, translation, linear deformation, rotation and angular deformation of fluid elements, vorticity, rotational and irrotational flows, circulation, velocity potential and stream functions, flow net and its characteristics, local, convective and substantial acceleration of fluid particles.

FLUID DYNAMICS- Concept of control mass and control volume, Reynolds transport theorem, conservation of mass, momentum equation, Euler's equation, Navier-Stokes equations. Derivation of Bernoulli's equations from Euler's equation and applications of momentum and energy equations (pitot tube, weirs and sudden head loss due to expansion), energy and momentum correction factors.

FUNDAMENTALS OF BOUNDARY LAYER - Boundary layer concept, applications of boundary layer in various fields, thicknesses of boundary layer, laminar and turbulent boundary layers, laminar sub layer, application of Momentum equation, stream lined and bluff bodies, integral momentum equation, Prandtl's boundary layer equations. Boundary layer on rough surfaces, boundary layer separation and methods to avoid separation, wake, concepts of drag and lift on submerged bodies, types of drags and its determination.

PIPE FLOW PROBLEMS - Friction loss in pipes, minor losses in pipes, concept of equivalent length and diameter of pipes, siphons, parallel and compound pipe lines, branching of pipe lines, pipe networks and methods of analysis, three reservoir problem, water hammer and methods of analysis.

DIMENSIONAL ANALYSIS AND MODELLING -Dimensions, different systems of units, dimensional homogeneity, Buckingham's pi-theorem, nondimensional numbers and their physical significance, Geometric, kinematic and dynamic similarities, model laws, model testing and its analysis, scale effects, undistorted and distorted models.

2. Water Resources Engineering

IRRIGATION ENGINEERING -Definition of irrigation, necessity, drainage problems of irrigation, advantages and disadvantages of irrigation, types of irrigation, quality of irrigation water, various methods of irrigation, suitability of various methods of irrigation, Bandhara irrigation.

WATER REQUIREMENTS OF CROPS -Classes and availability of soil water, available moisture depth, frequency of irrigation, relationship between duty Δ and base period, factors affecting duty, methods of improving duty, irrigation efficiencies, command areas, kharif, rabi and perennial crops, crop rotation, irrigation water requirement, design discharge of canal and storage capacity of reservoir based on irrigation requirement.

GRAVITY DAM -Design of gravity dam, principal and shear stresses, failure of dam and its stability, elementary & practical profile of the gravity dam, joints, galleries, shafts, foundation treatment.

EMBANKMENT DAMS -Types of embankment dams, factors affecting design of embankment dam, causes of failure of embankment dams, criteria of design of earth dams, computation of free board in embankment dam, seepage analysis of homogenous and zoned dams, seepage control through embankment dam and its foundation, stability analysis of the earth dam.

SPILLWAYS AND ENERGY DISSIPATION -Types of spillways, design aspects of ogee spillway, spillway gates, jump-height curve and tail water curves, different types of energy dissipaters.

HYDRAULIC STRUCTURE – Cross drainage works, canal regulation works, types, design aspects

3. Hydrology

PRECIPITATION AND ABSTRACTIONS - Mechanism of precipitation, types and forms of precipitation, measurement techniques, rain gauge network, variability in precipitation, estimation of missing data, test for consistency of rainfall record, rainfall hyetograph, rainfall mass curve, areal average rainfall, intensity duration curves, evaporation, factors affecting evaporation, evaporimeters, estimation of evaporation, evapotranspiration, measurement of evapotranspiration, initial loss, infiltration and infiltration indices.

RUN OFF AND HYDROGRAPH -Direct runoff and base flow; run off characteristics of streams, computation of runoff, rainfall-runoff relationships, components of hydrograph and factors affecting shape of hydrograph, base flow separation, effective rainfall hyetograph, unit hydrograph theory, derivation of unit hydrograph of different duration, synthetic unit hydrograph, IUH

STREAM GAUGING AND DESIGN FLOOD -Site selection for stream gauging, direct methods of discharge measurements, computation of design flood using rational, empirical, unit hydrograph and flood frequency methods.

GROUND WATER HYDROLOGY - Occurrence, distribution of ground water, specific yield of aquifers, movement of groundwater, Darcy's law, permeability, safe yield of a basin, compressibility of aquifer, storage coefficient, specific storage, hydraulics of wells under steady & introduction to unsteady condition in confined and unconfined aquifers, yield of wells, pumping and recuperation tests, types of tube wells.

FLOOD ROUTING -Reservoir and channel flood routing methods.

4. Open Channel Flow

BASIC CONCEPTS OF OPEN CHANNEL FLOW -Open channel flow vs pipe flow, classification of open channel flow based on space and time criteria, effect of viscosity and gravity; velocity distribution and pressure distribution in open channel, continuity equation, momentum equation and energy equation in open channel.

UNIFORM FLOW IN OPEN CHANNEL - Development of uniform flow, resistance law, factors affecting Manning's roughness coefficient, conveyance, section factor for uniform flow computations, computation of uniform flow, efficient channel sections, hydraulic exponent for uniform flow computations.

SPECIFIC ENERGY AND SPECIFIC FORCE -Specific energy, Specific energy curve and its limitations, critical depth and section factor for critical flow computations, open channel flow transitions, standing wave & Venturi flumes, control sections and hydraulic exponent for critical flow computations, specific force curve and its application in the analysis of hydraulic jump, hydraulic jump characteristics

GRADUALLY AND RAPIDLY VARIED FLOW -Assumptions in GVF analysis, dynamic equation of GVF, classification of channel slopes, GVF profiles, its identification and computation

Hydraulic jump in horizontal and sloped open channel bed and its characteristics

UNSTEADY OPEN CHANNEL FLOW- Wave celerity, classification of water waves according to relative depth, orbital motions, superposition, wave trains and wave energy, transformation of waves, dissipation of wave energy, positive and negative surges in rectangular channel, Momentum and Continuity equations (Saint Venant Equation).

SPATIALLY VARIED FLOW-Basic principles and assumptions, dynamic equation and analysis of flow profiles, Numerical integration method, Isoclinical method, spatially varied steady and unsteady surface flows.

MECHANICS OF SEDIMENT TRANSPORT- Nature of sediment problems, Origin and formation of sediments, individual and bulk properties of sediments, competent velocity, lift force and critical tractive stress concept on cohesion less and cohesive soils; regimes of flow; Resistance to flow in alluvial streams, resistance relations based on total resistance and division of resistance into grain and form resistance, preparation of stage discharge curves for alluvial streams, velocity distribution in alluvial channel, sediment Petrography (Sediment sampling)Hydraulic geometry of alluvial streams, bed level variation of alluvial streams, aggradations and degradation models, reservoir sedimentation, local scours.

5. Application of Geo spatial and computational Techniques

Remote Sensing Fundamentals of remote sensing - Interpretation - Equipments - Techniques of data acquisition – Satellites and sensors – Digital Image processing GPS Introduction to GPS - Working principle of GPS - Measurement and mapping techniques.

GIS Introduction - Geo referenced data - Data input & output - Data quality and management - GIS analysis functions - Implementation of GIS, Statistical Method.

Numerical Methods Finite difference schemes – Method of characteristics – Finite element method Advanced Techniques Genetic algorithm - Artificial Neural Network - Fuzzy logic – Hydro informatics.

References

1. Fox W.R. and McDonald, A.T., “Introduction to Fluid Mechanics”, Wiley and Sons Inc., New York, 1998.
2. Jain A K, “Fluid Mechanics including Hydraulic Machines”, Khanna Publishers, New Delhi, 2000.
3. Streeter V.L., Bedford K. and Wylie E. B., “Fluid Mechanics”, McGraw Hill Book Company Ltd., New York, 1998.
4. Chow V T, Maidment D R and Mays L W, “Applied Hydrology”, McGraw-Hill Book Company, New York, 1988.
5. Raghunath H. M., “Hydrology, Principles, Analysis and Design”, New Age International (P) Ltd, New Delhi, 2000.
6. K. Subramanya, “Engineering Hydrology”, Tata Mc-Graw Hill Publishing Co. Ltd., New Delhi, 1990.
7. Chaudhary Hanif M., Open Channel flow, Prantice-Hall of India Pvt. Ltd. New Delhi, 1993.
8. Chow V T, Open Channel Hydraulics, McGraw-Hill Book company, International
9. editions, New Delhi, 1973.
10. Subrmanya K, Flow in open channels, Second edition, Tata McGraw-Hill Publishing
11. Company Ltd., New Delhi, 2001
12. Ranga Raju K. G., Flow through Open channel, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1997.
13. Modi P N and Seth S M, “Hydraulics and Hydraulic Machines”, Standard Book House, Nai Sarak New Delhi, 2000.
14. Garde R. J. and Ranga Raju K. G., Mechanics of sediment transportation and alluvial stream problems, Third edition, New Age International (P) Limited, New Delhi, 2000.
15. Garde R. J., River morphology, New Age International Publisher, New Delhi-110042, 2006.
16. Lillesand T.M. and Kiefer R. W., Remote Sensing and Image Interpretation, John Willey & Sons, New York, 2004.
17. Stan Aronoff, Geographical Information Systems, WDL Publications, Ottawa, Canada, 1989.

6 Geotechnical Engineering

❖ Soil Properties

(Marks-35)

- Need for Soil Engineering Studies - Soil as an Engineering Material -Scope of Geotechnical Engineering.
- Elementary properties and their measurements - Constituents of soil - Phase diagram - Definitions Interrelationship – In situ determination of density - Relative density
- Classification of soil based on particle size - Soil consistency limits - Soil indices
- Definition - objectives - Factors affecting compaction - Laboratory tests - Zero air void Line - Field compaction control - Relative compaction
- Permeability - Darcy's law - Laboratory tests - Field tests - Permeability of stratified deposits – Seepage - Flow net - Quick sand condition

❖ Soil Strength, Compressibility & Stability

(Marks-40)

- Consolidation test – Significance - Consolidation Parameters - Consolidation Settlement
- Shear parameters - Coulomb's law of shear strength – various laboratory methods to evaluate strength parameters - Drainage conditions
- Definition,- Active - Passive and Earth pressure at rest conditions Coulomb's - Rankine's theories of earth pressure
- Infinite slope - Finite slope - Swedish method - Taylors stability number-Applications to design of earth dam, choice of shear parameters - Total and effective stress analysis and concept of factors of safety.

❖ Soil Exploration, Foundations, Bearing Capacity & Settlement

(Marks- 40)

- Purpose – Information - Objectives and Methods – Sampling - concept of stress distribution –
- Types of foundation Bearing capacity and settlement of foundations - Total settlement - Computation of settlement components - Pile foundation - Suitability of deep foundations - Load carrying capacity of pile - Static and dynamic formuii - Pile load test - Concept of group effect of piles for load carrying capacity.

❖ Ground Improvement

(Marks- 35)

- In situ densification of granular and consolidation of cohesive soils, Dynamic compaction, Compaction by sand piles, Blasting, Dynamic consolidation, Pre loading with sand drains.
- Stone columns, Methods of installation, Stabilization of Soft clays with lime piles.
- Earth reinforcement, Geo-synthetics, Geo-textile Applications of reinforced earth.

Books Recommended

- Arora K R, "Soil Mechanics & Foundation Engineering", Standard Publishers Ltd. 2002.
- Terzaghi , Peck .and Mesri " Soil Mechanics in Engineering Practice " 1996.
- Bowles J E, "Foundation Analysis & Design", McGraw Hill Inc., New York, 1988.
- Shroff A V "Soil Mechanics and Geotechnical Engineering, Taylor & Francis, 2003.
- Das B M, "Principles of Geotechnical Engineering", PWS Publishing Co., Boston, 1990.
- P. Purshottam Raj, "Ground Improvement Techniques".

7. Structural Engineering

Section – I (Marks – 50)

❖ **Behavior of structural elements subjected to various loadings:**

Representation of shear force and bending moment of beams, relationship of loads, shear force and bending moment, Theory of pure bending, bending stresses and shear stresses. Analysis of bending of curved bar, Analysis of rotating disc and cylinder. Relation between various elastic constants on body.

❖ **Advances in concrete technology:**

Cement and cement chemistry, Rheology of fresh concrete, Properties harden concrete and its testing methods, causes of deterioration in concrete and durability problems, cracking and its causes, Application of special concrete like Geo-polymer concrete, Self-compacting concrete, Fibre reinforced concrete, High volume fly-ash concrete, High strength concrete, High performance concrete, Light weight concrete, Pervious concrete etc., Utilization of plastic waste in concrete, Recent advances in repair and rehabilitation of concrete structures, Microstructure of concrete.

Section - II (Marks – 40)

❖ **Displacement of Statically Determinate Structures:**

Determination of slope and deflections of beams using successive integration method – Macaulay's method-conjugate beam method

❖ **Analysis of Indeterminate Structures with Displacement Based Methods:**

Stiffness approach for the analysis of truss, beam, and frame elements with special constructional aspects like support settlement, internal hinge, skewness of support, lack of fit of elemental length, temperature gradient etc. Definition of degree of freedom; Idealization of structure as SDOF system; Formulation of equation of motion for various SDOF systems; Free vibration of undamped systems; Free vibration of viscously damped systems; Damping in structures.

Section - III (Marks – 60)

❖ **Design of Steel Structures:**

Design of Tension and compression members, design of flexural members – Beams. Plastic analysis of structures. Connections with general design consideration and design of welded - Bolted connections.

❖ **Design of Concrete Structures:**

Materials for reinforced cement concrete (RCC), Design loads, Concrete structural systems, Basis of structural design, Principles of limit state design, Characteristics strength and design strength, idealized stress strain curve for materials, Design codes.

❖ **Limit state design of beams under flexure and shear:**

Limit state of Collapse in Flexure, Design parameters of stress block, Analysis of singly reinforced rectangular sections, Moment of resistance, Design of singly and doubly reinforced rectangular section, Analysis and design of flanged beam sections. Behavior of RC Beams under shear, Design shear reinforcement.

❖ **Limit state design of columns:**

Types of columns, Behavior of axially loaded RC Columns-Uniaxial and Biaxial loaded column, Practical provision on Reinforcement Detailing.

Books Recommended:

- Beer, F.P. and Johnston, E.R. "Vector mechanics for engineers: Statics and Dynamics", Tata McGraw-Hill, New Delhi.
- Desai, J.A. and Mistry, B.B. "Engineering Mechanics: Statics and Dynamics", Popular Prakashan, Surat.
- Subramanian R. (2007) "Strength of Materials", Oxford university press, pp. 880.
- Bansal R K (2018) "Strength of Materials", Laxmi publication pvt ltd. pp. 1160.
- Shetty M S (2010) "Concrete Technology", S. Chand & Company Ltd., pp. 624.
- Neville A M (2011) "Properties of Concrete", Pearson Education Limited pp. 872.
- Reddy C S (2007) "Basic Structural Analysis" 2nd edition, Tata Mc Graw Hill, New Delhi.
- Wang C K "Intermediate Structural Analysis" International edition, McGraw Hill, Singapore.
- Meghere A S and Deshmukh S K "Matrix method of Structural Analysis" Charotar Publishing House, Anand.
- Negi L S and Jangid R S "Structural Analysis", Tata Mc Graw Hill, New Delhi.
- Hibbler R C, "Structural Analysis", 6th edition, Pearson Prentice Hall, New Delhi.
- Gali A, Newville A M, Brown T G, "Structural Analysis – A Unified Classical and Matrix Approach", Sixth Edition, spon Press, UK.
- N. Subramanian: "Steel structure Design & Practice" Oxford University Press.
- Dugal S K "Design of Steel Structure", Tata Mc Graw Hill Publication, New Delhi, 2nd Edition.
- V L Shah & Curve "Design of steel structure", Structure Publication. Vidhyarthi Publication, Pune.
- Pillai S U, and Menon D, "Reinforced Concrete Design", 3rd edition, Tata Mc Graw Hill Publication Ltd, New Delhi.
- Sinha S. N. "Reinforced Concrete Design", 2nd edition, Tata Mc Graw Hill Publishing Co., Ltd, New Delhi.
- Shah H J, "Reinforced Concrete", Vol-I 6th Edition, Charotar Publishing House, Anand.
- Subramanian N, "Design of Reinforced Concrete Structures", Oxford University Press, New Delhi.