



Board of Studies in Civil Engineering

Structure and Syllabus for B.E. Civil 2012 Course (w.e.f. June, 2015)



Savitribai Phule Pune University

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Structure for B.E. Civil 2012 Course (w.e.f.June 2015)

Subject code	Semester – I								
	Subject	Teaching Scheme Hrs/Week			Examination Scheme				
		Lect	Tu	Pr	In-Semester Assessment	TW	Or	End - Semester Exam	Total
	Environmental Engineering II	3		2	30	--	50	70	150
	Transportation Engineering	3		2	30	50	--	70	150
	Structural Design and Drawing III	4		2	30	--	50	70	150
	Elective I	3		2	30	50		70	150
	Elective II	3			30			70	100
	Project	--	2			50			50
	Total →	16	2	8	150	150	100	350	750

Subject code	Semester – II								
	Subject	Teaching Scheme Hrs/Week			Examination Scheme				
		Lect	Tu	Pr	In-Semester Assessment	TW	Or	End - Semester Exam	Total
	Dams and Hydraulic Structures	3	--	2	30	---	50	70	150
	Quantity Surveying, Contracts and Tenders	3	--	2	30	--	50	70	150
	Elective III	3	--	2	30	50	--	70	150
	Elective IV	3	--	2	30	50	--	70	150
	Project	--	6		--	50	100	--	150
	Total →	12	6	8	120	150	200	280	750

Following will be the list of electives..

Semester I

Elective-I 1. Structural Design of Bridges 2. Systems Approach in Civil Engineering 3.. Advanced Concrete Technology 4. Architecture and Town Planning 5. Advanced Engineering Geology with Rock Mechanics	Elective-II 1. Matrix Methods of Structural Analysis 2. Integrated Water Resources and Planning 3. TQM & MIS in Civil Engineering 4. Earthquake Engineering 5. Advanced Geotechnical Engineering
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Semester II

Elective-III 1. Advanced Structural Design 2. Advanced Foundation Engineering 3. Hydropower Engineering 4. Air Pollution and control 5. Finite Element Method in Civil Engineering	Elective-IV 1 Construction Management 2. Advanced Transportation Engineering 3. Statistical Analysis and Computational Methods in Civil Engineering 4. Open Elective a). Plumbing Engineering b) Green Building Technology c) Ferrocement Technology d) Sub sea Engineering e) Wave Mechanics
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Environmental Engineering – II

Teaching Scheme: Lectures: 3 Hrs / week
Practical: 2 Hrs/week

Examination Scheme:
Paper In-sem. 30 Marks (1 hr),
Paper End-sem : 70 Marks (2.5 hr)
Oral : 50 Marks

Unit I

(6Hrs)

Sewage quantity: Collection and conveyance of sewage, sources of sewage, variations in sewage flow, Flow quantity estimation, Design of circular sanitary sewers. Pumping of sewage, necessity, location. Effect of change of life style on sewage quality.

Characteristics of sewage: Physical, chemical and biological characteristics, effluent discharge standards as per CPCB norms, interpretation and practical significance of test results.

Stream sanitation: Self purification of natural streams, river classification as per MoEF & CC, Govt. of India; Oxygen Sag Curve, Streeter - Phelps equation and terminology (without derivation and numerical).

Unit II

(6Hrs)

Sewage treatment: Introduction to sewage treatment, preliminary, primary, secondary and tertiary treatment, Process flow diagram for sewage treatment, Theory and design of screen chamber, Grit Chamber and Primary sedimentation tank as per the Manual of CPHEEO.

Unit III

(6Hrs)

Theory & design of secondary treatment units: Introduction to unit operations and processes for secondary treatment. Principles of biological treatments, important microorganisms in waste water & their importance in waste water treatment systems, bacterial growth, general growth pattern, growth in terms of bacterial numbers and bacterial mass. Kinetics of biological growth, cell growth, substrate limited growth, cell growth and substrate utilization, effect of endogenous metabolism.

Activated sludge process: Theory and design of ASP, sludge volume index, sludge bulking & control, modifications in ASP.

Trickling filter: Biological principle, different T.F media & their characteristics, design of standard rate and high rate filters using NRC formula, single stage & two stage filters, recirculation, ventilation, operational problems, control measures, theory of rotating biological contractors.

Unit IV

(6Hrs)

Low cost treatment methods:

Oxidation pond: Bacteria – algae symbiosis, design of oxidation pond as per the manual of CPHEEO, advantages & disadvantages of oxidation ponds.

Aerated lagoons: Principle, aeration method, advantages & disadvantages of aerated Lagoons, design of aerated lagoon.

Introduction and theory of Phytoremediation technology for wastewater treatment. Introduction and theory of root zone cleaning system

Unit V

(6Hrs)

Onsite Sanitation and Introduction to Package Sewage Treatment Plant: Working principle, advantages and disadvantages

Anaerobic digester: Principle of anaerobic digestion, stages of digestion, bio – gas production its characteristics & application, factors governing anaerobic digestion,. Dewatering of sludge by gravity thickener, sludge drying bed, decanters. Methods of sludge treatment and disposal, advantages & disadvantages. Up-flow Anaerobic Sludge Blanket (UASB) Reactor– Principle, advantages & disadvantages.

Unit VI

(6 Hrs)

Industrial waste water treatment: Methods of sampling. Equalization and neutralization. Application of preliminary, primary and secondary treatment for industrial wastewater as per the CPCB norms.

Sources of waste water generation from manufacturing process, characteristics of effluent, different methods of treatment & disposal of effluent for the following industries: Sugar, dairy and distillery. Discharge standards as per CPCB norms.

Term Work

A. Compulsory Assignment

1. Brief report on Sewer materials, choice of materials, testing of sewer pipes, sewer appurtenances.
2. Design of septic tank

B. Experiments

The term work shall consist of a journal giving details of at least 8 out of 12 of the following experiments conducted in Environmental Engineering laboratory, of which, **Sr.No.12 is compulsory.**

1. Solids -Total solids, suspended solids, volatile solids, settleable solids & non settleable solids.
2. Sludge Volume Index.
3. Dissolved oxygen.
4. Bio-Chemical Oxygen Demand.
5. Chemical Oxygen Demand.
6. Electrical Conductivity.
7. Determination of Phosphates by spectrophotometer.
8. Determination of Nitrates by spectrophotometer.
9. Determination of heavy metals like Cr⁶⁺ or Zn or Ni or Cd.
10. Determination of total nitrogen by kjeldal method
11. Visit to domestic / Industrial wastewater treatment plant & its detailed reports.

12. Computer aided design of Sewage Treatment Plant (STP) OR Effluent Treatment Plant (ETP) of Sugar or Dairy Industry using suitable software (C programming or any other suitable software).

Note: - Term Work should include a detailed analysis of practical interpretation, significance and application of test results.

Text Books

1. Environmental studies by Rajgopalan- Oxford University Press.
2. Waste Water Treatment & Disposal – Metcalf & Eddy - TMH publication.
3. Environmental Engg. - Peavy, Rowe - McGraw Hill Publication.
4. Waste Water Treatment – Rao & Dutta.

Reference Books

5. Waste Water Engg. – B.C. Punmia & Ashok Jain - Arihant Publications.
6. Water Supply & Waste Water Engg.- B.S.N. Raju – TMH publication.
7. Sewage Disposal & Air Pollution Engg. – S. K. Garg – Khanna Publication.
8. Environmental Engg. – Davis - McGraw Hill Publication
9. Manual on sewerage and sewage treatment – Public Health Dept., Govt. of India.
10. Standard Methods by APHA.

I.S. Codes

I.S. 3025 (all parts)

e - Resources

- i) <http://nptel.iitm.ac.in/courses-contents/IIT Kanpur and IIT Madras>.
- ii) <http://cpcb.nic.in>
- iii) <http://moef.nic.in>

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Transportation Engineering

Teaching scheme

Lectures: 3 hours/week

Practical: 2 hrs

Examination scheme

In semester exam: 30 marks---1 hour

End semester exam: 70 marks—2.5 hours

Term Work: 50 marks

Highway Engineering

Unit I

(6 hrs)

Introduction:

Role of transportation, scope of road transportation, highway development in India, necessity of highway planning and development plans e.g. Bombay plan, Lucknow plan.

Classification of road:

Classification of roads, road patterns, planning surveys and preparation of master plan based on saturation system, determination of road length by 3rd road development plan.

Traffic engineering:

Traffic characteristics-road user characteristics, vehicular characteristics (only name and significance) Traffic studies –name of various studies and their uses, accident studies-objectives, causes of accident, condition and collision diagram, and measures for the reduction in accidents. Traffic regulation and control devices-traffic signs, traffic signals (types merits and demerits) road markings. Traffic islands, types of road intersections (sketch merits and demerits). Parking facilities.

Unit II

(6 hrs)

Highway alignment:

Basic requirements of an ideal alignment and factors controlling it, engineering survey for highway location, special requirements for hill roads,

Geometric design and traffic engineering:

Design controls and criteria for geometric design, cross sectional elements, sight distance requirements, stopping distance, overtaking sight distance, overtaking zones with IRC recommendations, attainment of super elevation, radius of curves, methods of introduction of extra widening, widening of pavement on horizontal curves, horizontal transition curves- objects, necessity, types of transition curves, length and shift of transition curves. Design of vertical alignment, gradient and its type, IRC recommendations, grade compensation on horizontal curve, vertical curves: - crest and sag curves, types of summit curves, length of summit curve for SSD and OSD. Requirements, types of valley curves, length of valley curve for comfort and head light sight distance criteria.

Highway drainage:

Importance of highway drainage, subsurface and surface drainage systems, scope of arboriculture for highway.

Unit III

(6 hrs)

Highway materials:

Importance and properties of sub-grade, pavement component materials. Tests on aggregates. Bitumen: Types--cut back, tar, emulsion and tests, modified binders, bitumen mix design by Marshall Stability test, viscosity based gradation of bitumen

Pavement design:

Objects and requirements, types of pavements structures, functions of pavement components factors affecting pavement design, Design of flexible pavement by C.B.R. Method, IRC 37- guidelines design of rigid pavements, factors affecting design & analysis of stress- wheel load stress & temp. Stress, critical combination of stress, IRC 58- design guidelines, types of joints, requirements of joints.

Construction:

Construction process of WBM, WMM, GSB (Mix design). Introduction to bituminous works such as prime coat, tack coat, seal coat, MPM, AC or BC, BM, DBM and premix carpet.

Airport Engineering:

Unit IV

(6 hrs)

Introduction:

Advantages and limitations of air transportation. Aeroplane component parts and important technical terms.

Airport planning:

Aircraft characteristics, which influence judicious and scientific planning of airports, Selection of sites, survey and drawings to be prepared for airport planning.

Airport layout:

Characteristics of good layout, runway configuration, airport obstruction, location of terminal buildings, aprons and hangars. Zoning requirements regarding permissible heights of constructions and landing within the airport boundary.

Runways and taxiways:

Runway orientation, wind coverage, use of wind rose diagram, basic runway length, corrections for elevation, temperature and gradient as per ICAO and FAA recommendation. Airport classification by ICAO.

Bridge Engineering

Unit V

(6 hrs)

Introduction:

Classification of bridges, components of bridges, preliminary data to be collected during investigation of site for bridges, determination of discharge – empirical formula, direct methods, economical span, afflux, HFL, scour depth and clearance, locations of piers and abutments, factors influencing the choice of bridge super structure, approach roads.

Loads on bridges:

Brief specifications of different loads, forces, stresses coming on bridges, IRC load specification, requirements of traffic in the design of highway bridges

Substructure:

Abutment, Piers, and wing walls with their types based on requirement and suitability.

Types of bridges**Various types of bridges:**

- Culvert: Definition, waterway of culvert and types.
- Temporary bridges: Definition, materials used brief general ideas about timber, floating and pantoon bridges.
- Movable Bridges: Bascule, cut boat, flying, swing, lift, transporter and transverse bridges, their requirement and suitability.
- Fixed span bridges:
Simple, continuous, cantilever, arch, suspension, bowstring girder type and rigid frame and cable stayed bridges, materials for super structure.

Bearing:

Definition, purpose and importance. Types of bearings with their suitability.

Erection of bridge super structure and maintenance:

Introduction to different techniques of erection of bridge super structure and maintenance of bridges.

Term work:

Term work shall consist of the following:

A. Practical:**I. Tests on Aggregate (Any Six) :**

- Aggregate Impact Value Test
- Aggregate Crushing Strength Test
- Los Angeles Abrasion Test
- Shape Test (Flakiness Index and Elongation Index)
- Specific Gravity and Water Absorption Test by basket method
- Stripping Value Test
- Soundness Test

Text Books

- Highway engineering-Khanna,Justo
- Highway engineering - Paul Wright and Karen Dixon-- Wiley India
- Principles of Highway Engineering and Traffic Analysis (4th edition)
- F. L. Mannering, Scott S. Washburn-- Wiley India
- Design of Bridges, N. Krishna Raju, Oxford and IBH Publishing Company Pvt. Ltd.
- Design of Bridge Structures, M.A. JayaramPrentice-Hall Of India Pvt. Limited

Reference Books

- Highway Engineering - Laurence I Hewes & Clarkson H Oglesby
- Traffic Engineering and Transport Planning - L R Kadiyali.
- Fundamentals of Transportation Engineering - C. S. Papacostas.
- Introduction to Transportation Engg. and Planning – Morlok E K, McGraw-Hill company.
- Fundamentals of Traffic flow Theory – Drew, McGraw-Hill book co

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Structural Design III

Teaching Scheme:

Lectures: 4 Hrs / week

Practical: 2 Hrs/week

Examination Scheme:

In sem :30 + End sem : 70Marks

Oral : 50 Marks

Duration : Insem : 1.5 Hr

End sem : 3 Hrs

Unit 1

Prestressed concrete - Analysis

Introduction, Basic concepts, materials-various Pretensioning and post tensioning systems, concept of losses, Stress calculations, and concept of cable profile.

Unit 2

Prestressed concrete - Design

Design of post tensioned prestressed concrete simply supported rectangular and flanged sections for flexure and shear including end block.

Design of one way and two way post tensioned slabs (Single panel only)

Unit 3

Earthquake force calculation and analysis and design of frames

Review of methods of analysis for frames subjected to gravity and lateral loads. Earthquake loads by seismic coefficient method. Estimation of combined effect of lateral forces and vertical loading on multi storeyed frames. Design any intermediate continuous beam of the frames for combined effect of loadings

Unit 4

Earth retaining structures

Introduction, Functions and types of retaining walls. Analysis and design of RCC cantilever type of retaining wall for various types of backfill conditions.

Unit 5

Combined footings

Introduction, necessity and types of combined footings, design of slab type and slab-beam type of combined footing.

Unit 6

Liquid retaining structures

Introduction, types, function, codal provisions, methods of analysis and design of circular, square, and rectangular water tanks resting on ground.

Note: Design based on above unit shall conform to latest versions of IS 456, IS 875, IS 1343, IS 3370, IS 1893, IS 13920.

Term Work

Term work shall be based on the above syllabus. It consists of

- 1) Assignment on Loss calculation unit 1
- 2) Assignment on stress calculation unit 1

- 3) Design and detailing of design of prestressed girder from Unit 2
- 4) Assignment on Earthquake force calculation from unit 3
- 5) Design and detailing of frame (beam only) from Unit 3
- 6) Design and detailing of retaining wall for any type of loading from Unit 4
- 7) Design and detailing combined footing from Unit 5
- 8) Design and detailing of ground resting water tank from Unit 6
- 9) Minimum five full imperial sheets based on four projects of RCC and one project of pre-stressed concrete.

10) Report on analysis of assignment on unit 3 by software or computer program

- 11) Two site visit reports one each of R.C.C. and another P.S.C. Oral Examination: Oral based on above term work

12) There should separate design data for a group size of maximum four students.

Text Books

1. Limit state theory and design of reinforced - Dr. V. L. Shah and Dr S. R. Karve - Structures Publications, Pune
2. Fundamentals of Reinforced Concrete- N.C. Sinha, S.K. Roy – S. Chand & Co. Ltd
3. Advanced design of structures- Krishnaraju - Mc Graw Hill
4. Design of Prestressed concrete structures- T. Y. Lin.
5. Prestressed Concrete- N. Krishna Raju – Tata Mc Graw Hill Publication Co.

Reference Books

6. Comprehensive RCC Design - Punmia, Jain & Jain - Laxmi Publications.
7. Design of design of reinforced Concrete structures- M. L. Gambhir -PHI
8. Reinforced Concrete, Vol I- Dr.H J. Shah Charotar Publishing House
9. Prestressed Concrete – A Fundamental Approach- Edward Nawy – PHI.
10. Reinforced concrete design- Pillai and Menon TMH

I.S. Codes

1. IS: 456: Indian Standard code of practice for plain and reinforced concrete, BIS, New Delhi.
2. IS: 1343: Indian Standard code of practice for Prestressed concrete, BIS, New Delhi.
3. IS: 1893: Indian Standard Code of practice for criteria for Earthquake resistant design of structures, BIS, New Delhi.
4. IS: 3370-Indian Standard code of practice for concrete structures for storage of liquids, BIS, New Delhi.

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Elective I: (1) Structural Design of Bridges

Teaching Scheme:

Lecture: 3 hours per week

Practical : 2 hours per week

Examination scheme:

Term work: 50 marks

In-sem. Exam.: 30 marks (1 hrs)

End Sem. Exam.: 70 marks (2.5 hrs)

Unit 1

Introduction to RC highway bridges and steel railway bridges: Types of bridges, classification, IRC codal provisions for RC highway bridges, IRS codal provisions for railway steel bridges, loading standards.

Unit 2

RC highway bridges: T-beam deck slab bridges – Deck slab: Structural configuration, Piegaud's method, analysis and design of deck slab.

Unit 3

RC highway bridges: T-beam deck slab bridges – Post tensioned girders: Load distribution on longitudinal and cross girders, methods of analysis, analysis and design of longitudinal and cross girders.

Unit 4

Railway steel bridges – Truss bridges: Structural configurations, loads and load combinations, analysis and design of truss elements, longitudinal and cross-girders, bracing systems.

Unit 5

Bearings: Function of bearings, types of bearings, design of steel bearings and elastomeric bearings.

Unit 6

Sub-structure: Function, loads, analysis and design of RC abutments and piers.

Note: The designs should conform to the latest codal provisions.

Term Work

a) One project on RC highway bridges which shall include - the design of deck slab, longitudinal girder, cross-girder, bearings and abutment and pier.

The detailing shall be shown in at least three full imperial sheets.

b) One project on railway steel bridges which shall include – the design of truss elements, longitudinal girder, cross-girder, and bearings.

The detailing shall be shown in at least two full imperial sheets.

c) The term work can be prepared in a group of not more than four students in a group.

d) Report of at least two site visits covering the contents of the syllabus.

e) One of the above projects can be done using any drafting software.

Reference Books

Design of Bridges, N. Krishna Raju, Oxford and IBH Publishing Company Pvt. Ltd.

Design of Bridge Structures, M.A. JayaramPrentice-Hall Of India Pvt. Limited

Prestressed Concrete, N. Krishna Raju, Tata-McGraw Hill

Design of Steel Structures, Ramachandra, Standard Publications New-Delhi

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Elective I (2)- Systems Approach in Civil Engineering

Teaching scheme

Lectures: 3 hours/week

Practical: 2 hrs/week

Examination scheme

In semester exam: 30 marks---1 hour

End semester exam: 70 marks—2.5 hours

Term Work: 50 marks

Unit 1: Introduction of systems approach

(6 Hrs)

Introduction to System approach, Operations Research and Optimization Techniques, Use of systems approach in Civil Engineering, Methods, Introduction to Linear and Non linear programming methods (with reference to objective function, constraints), Local & Global optima, unimodal function, convex and concave function

Unit 2: Non linear programming

(6 Hrs)

Single variable unconstrained optimization: Sequential Search Techniques-Dichotomous, Fibonacci, Golden section

Multivariable optimization without constraints-The gradient vector and Hessian Matrix, Gradient techniques, steepest ascent/decent technique, Newton's Method

Multivariable optimization with equality constraints - Lagrange Multiplier Technique

Unit 3: Stochastic Programming

(6 Hrs)

Sequencing- n jobs through 2, 3 and M machines

Queuing Theory : elements of Queuing system and it's operating characteristics, waiting time and ideal time costs, Kendall's notation, classification of Queuing models, single chanel Queuing theory : Model I (Single channel Poisson Arrival with exponential services times, Infinite population (M/M/1) : (FCFS/ ∞/∞)

Simulation : Monte Carlo Simulation

Unit 4: Dynamic programming:

(6 Hrs)

Multi stage decision processes, Principle of optimality, recursive equation, Applications of D.P.

Unit 5: Linear programming (A)

(6 Hrs)

Formulation of Linear optimization models for Civil engineering applications. The simplex method, Method of Big M, Two phase method, duality

Unit6: Linear programming (B)

(6 Hrs)

The Transportation Model and its variants, Assignment Model, and its variants

Term Work

1. One exercise/assignment on each unit. Out of these any one exercise/assignment to be solved using Computer
2. One exercise on formulation of a problem applicable to any field of Civil Engineering, requiring use of LP/ NLP/ DP. Formulation of objective function and constraints (No solution)

Text Books

1. Engineering Optimization: Methods and Application-- A. Ravindran, K. M. Ragsdell—
Wiley India
2. Engineering Optimization by S.S.Rao
3. Operations Research by Hamdy A. Taha
4. Quantitative Techniques in Management by N.D. Vohra (Mc Graw Hill)
- 5 Operations Research by Premkumar Gupta and D.S.Hira, S. Chand Publications (2014).

Reference Books

- 6.Topics in Management Science by Robert E. Markland(Wiley Publication)
7. An Approach to Teaching Civil Engineering System by Paul J. Ossenbruggen
- 8 A System Approach to Civil Engineering Planning & Design by Thomas K. Jewell
(Harper Row Publishers)

e - Resources

1. Mathematical Model for Optimization (MMO Software)
2. nptel.iitm.ac.in/courses/webcourse-contents/IISc-Bang/OPTIMISATION
METHODS/New-index1.html

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Elective I (3)- Advanced Concrete Technology

Teaching scheme

Lectures: 3 hours/week

Practical: 2 hrs/week

Examination scheme

In semester exam: 30 marks---1 hour

End semester exam: 70 marks—2.5 hours

Term Work: 50 marks

Unit I

Cement and its types: general, hydration of cement, alkali aggregate reaction. Grading curves of aggregates, Manufactured sand as fine aggregate, copper slag as fine aggregate
Concrete: properties of concrete, w/b ratio, gel space ratio, Problems on maturity concept, aggregate cement bond strength, Green concrete, Guidelines for Quality control & Quality assurance of concrete, Effect of admixtures.

Unit II

Structural Light weight concrete, ultra light weight concrete, vacuum concrete, mass concrete, waste material based concrete, sulphur concrete and sulphur infiltrated concrete, Jet cement concrete (ultra rapid hardening), gap graded concrete, high strength concrete, high performance concrete, Self curing concrete, Pervious concrete.

Unit III

Design of high strength concrete mixes, design of light weight aggregate concrete mixes, design of flyash cement concrete mixes, design of high density concrete mixes, Design of pumpable concrete mixes, Design of self compacting concrete.

Advanced non-destructive testing methods: ground penetration radar, probe penetration, break off maturity method, stress wave propagation method, electrical/magnetic methods, nuclear methods and infrared thermographs.

Unit IV

Historical development of fibre reinforced concrete, properties of metallic fibre, polymeric fibres, carbon fibres, glass fibres and naturally occurring fibres. Interaction between fibres and matrix (uncracked and cracked matrix), basic concepts and mechanical properties: tension and bending.

Unit V

Properties of hardened frc, behaviour under compression, tension and flexure of steel fibres and polymeric fibres, GFRC, SFRC, SIFCON, -development, constituent materials, casting, quality control tests and physical properties.

Unit VI

Ferrocement: Properties & specifications of ferrocement materials, analysis and design of prefabricated concrete structural elements, manufacturing process of industrial concrete elements, precast construction, erection and assembly techniques.

Termwork / Labwork:

The Termwork / Labwork will be based on completion of assignments / practicals / reports of site visits, confined to the course in that semester.

1. Concrete mix design and production in lab of any one – Self compacting concrete, Fiber reinforced concrete, light-weight concrete, high strength or ultra-high strength concrete . Comparison with traditional concrete mix is to be clearly stated in the report.

2. Cost analysis (material, labour, equipment, others) of any type of concrete for lab, in-situ and RMC production.
3. Perform any two Fresh (workability tests – Slump Flow Test, T-50, J-Ring, Visual Stability Index, Column Segregation, L-Box, U-box) and Hardened (Compressive, tensile, flexural) properties tests on any high performance concrete.
4. Any one experiment on any one of the topics – NDTs; Microscopic examination of cement/concrete; Performance study of any one admixture (Mineral/Chemical) in concrete.
5. Write a review on any recent research article from standard peer-reviewed journal.
6. Visit reports on minimum two site visits - exploring the field and practical aspects of concrete technology.
7. Report on at least one patent (national/international)– on any topic related to concrete technology.

Note: - Term Work should include a detailed analysis of practical interpretation, significance and application of test results including above contents and site visit report in form of journal.

Text books

1. Concrete Technology --M.S. Shetty, S. Chand Publications.
2. Concrete Technology -- A R Santhakumar, Oxford University Press.
3. Concrete technology -- M. L. Gambhir, Tata Mcgraw Hill Publications.
4. Fiber Reinforced Cement Composite- P.N.Balguru & P.N.Shah.
5. Concrete: Microstructure, Properties and Materials-- P. Kumar Mehta and P. S. M. Monteiro-- Tata Mc-Graw Hill Education Pvt. Ltd.

Reference Books

1. Handbook on Advanced concrete Technology Edited by N V Nayak, A .K.Jain, Narosa Publishing House .
2. Properties of concrete by A. M. Neville, Longman Publishers.
3. Concrete Technology by R.S. Varshney, Oxford and IBH.
4. Concrete technology by A M. Neville, J.J. Brooks, Pearson
5. Ferrocement Construction Manual-Dr. D.B.Divekar-1030, Shivaji Nagar, Model Colony, Pune
6. Concrete Mix Design-A.P.Remideos--Himalaya Publishing House (ISBN-978-81-8318-996-5
7. Concrete, by P. Kumar Metha, Gujrat Ambuja.
8. Learning from failures ---- R.N.Raikar
9. Structural Diagnosis ---- R.N.Raikar
10. Concrete Mix Design---Prof. Gajanan Sabnis

General Reading suggested: 1) Codes : i)IS 456 ii)IS 383 iii)IS 10262-2009 iv)IS 9103

2) Ambuja cement booklets on concrete Vol .1 to 158

3) ACC booklets on concrete

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Elective I (4)- Architecture and Town Planning

Teaching scheme

Lectures: 3 hours/week

Practical: 2 hrs/week

Examination scheme

In semester exam: 30 marks---1 hour

End semester exam: 70 marks—2.5 hours

Term Work: 50 marks

Unit I:

- Principles and elements of Architectural Composition,
- Qualities of Architecture: user friendly, contextual , ecofriendly, utility of spaces, future growth etc.
- Role of “Urban Planner and Architect” in planning and designing in relation with spatial organization, utility, demand of the area and supply

Unit II:

- Landscaping : importance , objectives, principles, elements, material (soft and hard),
- Urban renewal for quality of life and livability.
- Importance of sustainable architecture with case study

Unit III:

- Goals and Objectives of planning; components of planning; benefits of planning
- Levels of planning: Regional plan , Development Plan, Town Planning Scheme,
- Neighbourhood plan ; Types of Development plans: Master Plan, City Development Plan, Structure Plan

Unit IV:

- Various types of civic surveys for DP : demographic, housing, land use, Water Supply & sanitation, etc.,
- Planning agencies for various levels of planning. Their organization and purpose (CIDCO-MHADA-MIDC, MMRDA/ PMRDA etc).,
- Traffic transportation systems: urban road, hierarchy, traffic management, Intelligent Transport Systems.

Unit V:

- Legislative mechanism for preparation of DP: MRTP Act 1966
- UDPI guidelines (for land use, infrastructure etc), SEZ, CRZ, Smart City Guidelines

Unit VI :

- Special townships, Land Acquisition Rehabilitation and Resettlement Act 2013.
- Application of GIS, GPS, remote sensing in planning.

Term Work: - 50 Marks

Sr. no. 1 and 2 are compulsory and any four from remaining.

- 1 Study and analysis of Development Plan with respect to land use , services, infrastructure, street furniture, housing etc. (group work)
2. Neighborhood- planning (group work)
- 3 Report on contribution of Engineers, Planners and Architects in post independence India (individual work)
- 4 Report on any existing new towns and planned towns like new Mumbai, Gandhinagar, PCNTDA etc.(infrastructure, disaster management etc), (individual work)

- 5 Study of salient features of urban renewal schemes (group work)
- 6 Study of any existing town planning scheme (group work)
- 7 Smart City approaches (individual work)
- 8 Study of Special Townships: (site visit) (group work)
- 9 Study of urban housing and housing change (group work)

Text Books:

- Town Planning By G K Hiraskar
- Town Planning By S Rangwala
- Building Drawing and Built Environment- 5 Th Edition – Shah , Kale , Patki
- Planning Legislation By Koperdekar And Diwan.
- G. K. Bandopadhyaya , “Text Book of Town Planning”.
- Climate Responsive Architecture – Arvind Krishnan.
- Introduction To Landscape Architecture By Michael Laurie

Reference Books

- M RTP Act 1966
- Manual Of Tropical Housing And Building By Koenigsbeger
- Sustainable Building Design Manual
- UDPFI Guidelines
- “The Urban Pattern: City planning and design” by Gallion and Eisner.
- Design of cities by Edmond bacon
- LARR Act 2013
- MoUD By GoI
- NRSA
- CIDCO, MHADA, MIDC, MMRDA, PMRDA
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Elective I-(5) Advanced Engineering Geology with Rock Mechanics

Teaching scheme

Lectures: 3 hours/week

Practical: 2 hrs/week

Examination scheme

In semester exam: 30 marks---1 hour

End semester exam: 70 marks—2.5 hours

Term Work: 50 marks

Unit I : Indian Stratigraphy, Geology applied to Civil Engineering Practices

1 *Indian Stratigraphy:* **4**

Distribution and Geological characters of Major rock formations of India, Geological Map of India with special reference to Maharashtra, Seismic Zones of India, Engineering characters of major rock formations of India.

2 *Geology applied to Civil Engineering Practices:* **2**

Importance of geological studies in engineering investigations, precautions necessary to avoid misleading conclusions likely to be drawn while interpreting drilling data, dependence of design on geological features of project site.

Unit II: Subsurface Explorations for Water Retaining Structures; Geological Foundation

Treatments for various Civil Engineering Projects, Tail Channel Erosion.

3 *Subsurface Explorations for Water Retaining Structures:* **2**

Various Physical and Mechanical properties of rocks affecting strength & water tightness of them from foundation point of view. Effect of weathering, deterioration of rock masses on exposure to atmosphere & hydrothermal alteration of rocks on water retaining structures & suitable treatment for such rocks. Case studies illustrating economics made possible by proper geological studies & wasteful expenditure or difficulties resulting from their negligence.

4 *Geological Foundation Treatments for various Civil Engineering Projects:* **2**

Foundation investigations during construction for determining the foundation treatment for adverse geological features. Determination of foundation levels. Correction of adverse features by means of various techniques such as grouting etc. for improving strength of weak & fragmented rocks. Curtain grouting for preventing leakage through foundation rocks. Determining depths & zones of consolidation & curtain grouting. Foundation treatment for fractures having different manifestation, jointed rocks.

5 *Erosion of Tail Channels:* **2**

Erosion of tail channel as factor in selecting site for spillway. Causes of rapid erosion of tail channels of side spillways. Geological conditions leading to tail channel erosion. Case studies

Unit III: Geohydrological characters of major rock formations of India; Geological process of Soil formations

6 *Geohydrological characters of major rock formations of India:* **4**

- Geohydrological characters and factors affecting the water bearing structures of various rocks in India. Introduction to morphometric analysis of river system. Various methods of water conservation techniques, adverse aspects of tube wells, bore wells and dug wells. Geological aspects of conservation of water, artificial recharge, rainwater harvesting and watershed development & necessity of geological studies for such schemes. Illustrative case studies.
- 7 ***Geological Process of Soil formations:*** 2
 Rock weathering conditions favorable for decomposition & disintegration, Residual & transported soils. Effect of climate on formation of soil. Soil profile of various states in India.
- UNIT IV Rock Mechanics and Geophysical techniques.**
- 8 ***Rock Mechanics:*** 4
 General principles of rock mechanics. Dependence of physical and mechanical properties of rocks on geological characters. Various laboratory testing methods. Calculation of R.Q.D. Joint Frequency Index, Various Methods of Geomechanical classifications of rocks such as Terzaghi, U.S.B.M, R.M.R., R.S.R., Q. system, Deer and Miller, Bieniawski's Geomechanical classification etc. and computation of representative rock formation such as DTB.
- 9 ***Geophysical techniques :*** 2
 Various methods of Geophysical Exploration like Electrical Resistivity methods, Seismic method of exploration as applied to engineering investigations such as determination of thickness of overburden, locating ground water potential zones
- Unit V: Engineering Geological investigation for Tunnels and Bridges**
- 10 ***Engineering Geological investigation for Tunnels:*** 4
 Variations in methodology of investigation for different types of tunnels for different purposes, location, spacing, angles & depths of drill holes suitable for different types of tunnels. Difficulties introduced in various geological formation and their unfavourable field characters. Standup time of rock masses and limitations of it. Dependence of protective measures such as guniting, rock bolting, shotcreting, steel fiber shotcreting, permanent steel supports, lagging concreting & contact grouting above permanent steel supports on geological conditions. Illustrative case studies.
- 11 ***Bridges:*** 2
 Investigation for bridge foundation, difference in objectives of investigation of bridge foundation. Computing safe bearing capacity for bridge foundation based on nature & structure of rock. Foundation settlements. Case studies.
- UNIT VI : Resource Engineering ,Role of Geology in planning and development**
- 12 ***Resource Engineering:*** 2
 Deccan Trap basalts as construction material. Use of compact basalt & amygdaloidal basalts as rubble for masonry & metal for concrete & pavement quality concrete. Use of Basalt fibre during construction.

- Illustrative case studies.
- 13** ***Role of Geology in planning and development:*** **2**
Influence of geological factors upon urban development & planning ,locating non-renewable resources and geothermal energy.
- 14** ***Earthquakes and tectonics:*** **2**
Seismicity of Indian sub continent. Earthquakes occurring in the areas of some dams & RIS theories.

Practical Work / Term Work

- I) Study of Geological map and seismic zonation map of India **(2 Practical)**
- II) Interpretation of drill hole data
Logging of drill core, preparation of Litho logs & interpretation of drill data. Preparing geological cross sections from drill hole data & using them for designing of civil engineering structures representing following case studies.
1. Dipping sedimentary formation
 2. Faulted region
 3. Folded region
 - 4 Locating spillway on Igneous rocks
 5. Tunnels in Tectonic areas
 6. Tunnels and open cuts in non-tectonic areas **(6 Practical)**
- III) Study of some parameters of Morphometric Analysis of some tributaries of river, (Toposheet will be made available by the college) **(1 Practical)**
- IV) Study of Soil Profile of any region. **(1 Practical)**
- V) Use of electrical resistivity method for determining depth of bedrock. **(1 Practical)**
- VI) Computation of RQD & Joint Frequency Index **(1 Practical)**
- VII) A compulsory guided tour to study geological aspects of an engineering projects & writing a report based on studies carried out during visits to civil engineering projects.

Note:

**** Class test will be held in the last week of every month**

**** Field visits will be made to different places around study area and one long study tour to important geological place.**

The practical journal will be examined as term work.

Reference Books and Text Books:

1. Jaeger – Rock Mechanics in Engineering, Cambridge Univ Press London, 1990.
2. Goodmann – Principles of Rock Mechanics.
3. Bieniawski Z. T. - Engineering Classification of jointed Rock Masses.
4. Dr. Dobbrin - Introduction to Geophysics.
5. Goodmann – Engg. Geology.
6. Megaw T. M.& Tunnels: Planning, Design, Construction
7. J. V. Bartlett - Int. ED, Ellis Horwood ltd. John Willey & Sons .
8. Skinner B. J: The Dynamic Earth, An Introduction to Phy & Porter S. C Geology John Willey & Sons. NY 1989
9. Introduction to Rock Mechanics by B. P. Verma-Khanna Pub New Delhi

10. Environmental Geology by Waldiya
11. Environmental Geology – Keller, Prentice – Hall Publication.

Handbooks

- a. Gupte R. B. (1980) – P. W. D. Handbook Chapter –6, Part-II ‘Engineering Geology Government of Maharashtra.
- b. Tunneling India '94, “Central Board of Irrigation and Power”, New Delhi
- c. Manual on Rock Mechanics, Central Board of Irrigation and Power, New Delhi, 1988.
- d. Handbook of Geological terms, geology and Physical Geology, David page, University of Michigan. USA.
- e. Handbook of Geology in Civil engineering, Robert Fergusson , Legget, Mc-Graw hill.
- f. Geotechnical Engineering handbook, Robert day, Mc- Graw hill, ISBN 0-07-137782-4

I. S. Codes

- i) IRC code of practice for Road Tunnels. IRC-78-2000; IS-12070; IS-1336 Part I and II.
- ii) I. S. 4453-1967 Code of practice for Exploration, pits, trenches, drifts & shaft.
- iii) I. S. 6926-1973 Code of practice for diamond drilling for site investigation river valley project.
- iv) I. S. 4078-1967 Code of practice for Logging and Storage of Drilling Core.
- v) I. S. 5313-1969 Guide for core drilling observation.

e- Resources

1. www.ebd.co.in/undergraduate/eng.
2. www.library.iisc.ernet.in
3. www.iitb.ac.in
4. www.nptel.iitm.ac.in

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Elective II (1)- Matrix Methods of Structural Analysis

Teaching scheme

Lectures: 3 hours/week

Examination scheme

In semester exam: 30 marks---1 hour

End semester exam: 70 marks—2.5 hours

Unit I: Computational Techniques

6 Hrs

Review of matrix algebra, computer oriented numerical methods-Gauss elimination, Gauss Jordan and Gauss Seidel. Computer algorithm and flowcharts of above methods

Unit II: Flexibility matrix method for trusses, beams and frame

6 Hrs

Degree of static indeterminacy, flexibility, selection of redundant, flexibility matrix, analysis of pin jointed indeterminate trusses, continuous beams and simple portal frames involving not more than three unknowns.

Unit III: Stiffness matrix method for bars and trusses

6 Hrs

a) Degree of kinematic indeterminacy (degrees of freedom), local and global coordinate systems, stiffness matrices of a axially loaded bar members, global stiffness matrix, structure approach, member approach, analysis of determinate/indeterminate bars involving not more than three unknowns

b) Stiffness matrices of a truss member with four DOF, transformation matrix, global stiffness matrix, analysis of determinate/indeterminate trusses involving not more than three unknowns

Unit IV: Stiffness matrix method for beams and frames

6 Hrs

a) Stiffness matrix for a beam member, member and structure approach problems involving not more than three unknowns

b) Stiffness matrix for a portal frame member, transformation matrix, member and structure approach problems involving not more than three unknowns

Unit V: Stiffness matrix method for grid structures

6 Hrs

Stiffness matrix method for analysis of orthogonal grid structure, member stiffness matrix, transformation matrix, member and structure approach, problems involving not more than three unknowns

Unit VI: Stiffness matrix method for 3D structures and FDM

6 Hrs

a) Stiffness matrix method for the analysis of space truss, member stiffness matrix, problems involving not more than three unknowns, Formation of stiffness matrix of space frame element (no numerical),

b) Applications of finite difference method (FDM): Determine deflection and moments in beams, critical buckling load of columns.

Elective II (2)- Integrated Water Resources Planning & Management

Teaching Scheme: Lectures: 3 Hrs / week

Examination Scheme:

Paper In-sem. 30 Marks (1 hr),

Paper End-sem : 70 Marks (2.5 hr)

Unit1:

(6 Hrs)

a) Introduction :World water resources, water resources in India, water as finite resource, variability of water in time & space, history of water resources development, water infrastructure-problems and perspectives, present institutional framework for water management.

b) Water laws: Constitutional provisions, National Water Policy, riparian rights / ground water ownership, prior appropriation, permit systems, acquisition and use of rights, scope for privatization.

Unit2: Economics & Paradigm shift in water management

(6 Hrs)

a) Economics of water :Water as economic good, intrinsic value, principles of water pricing & water allocation, capital cost, opportunity cost, internal rate of return, benefit cost analysis, principles of planning and financing of water resources project : Discussion on any two case studies.

b) Paradigm shift in water management:

Global and national perspectives of water crisis, water scarcity, water availability and requirements for human and nature, concepts of 'blue water', 'Green water', and 'virtual water', and their roles in water management. Sustainability principles for water management, framework for planning a sustainable water future.

Unit3: Basin scale hydrology

(6 Hrs)

a) Estimation of surface water, estimation of ground water draft/recharge import/export of water (inter basin water transfer), recycling and reuse and storage, control of water logging, salinity, & siltation of storages.

b) Flood & Drought management: causes of floods, structural and non-structural measures, mitigation plan, flood damage assessment, use of geoinformatics for flood management. Types of droughts, severity index, drought forecasting, damage assessment, mitigation plan, use of geoinformatics for drought management

Unit 4: water demand and supply based management

(6 Hrs)

a) Consumptive & non consumptive demands, irrigation demand estimation, water utilization, irrigation efficiency, water management in irrigation sector,

b) demand estimation in hydro/thermal/nuclear power sector, estimation & forecasting of water demands of domestic & industrial sector, navigation and recreational water demands

Unit 5: Environmental and social aspects

(6 Hrs)

a) Environmental management: protection of vital ecosystem, water requirements for environmental management, aquaculture, minimum flows, water quality management for various uses.

b) Social impact of water resources development: direct/ indirect benefits, employment generation, industrial growth, agro-industry, enhanced living standards, education & health, co-operative movement, management of rehabilitation & resettlement.

Unit6: Basin planning & Watershed management (6 Hrs)

a) Perspective plan for basin development & management, Decision support system for Integrated Water Resources Management (IWRM), use of data driven techniques like Artificial Neural Networks, Genetic programming, Model Tree in water resources planning, development & management.

b) Watershed Management:

Watershed definition, classification of watersheds, integrated approach for watershed management, role of RS & GIS in watershed management, soil and water conservation- necessity- soil erosion- causes- effects-remedial measures, contour bunding- strip cropping- bench terracing-check dams.

Text Books

- 1) Water Resources Systems Engg, D. P. Loucks, Prentice Hall
- 2) Water Resources Systems Planning and Management, Chaturvedi, M.C. Tata McGraw Hill
- 3) Economics of Water Resources Planning, James L.D and Lee R.R, McGraw Hill
- 4) Water resources hand book; Larry W. Mays, McGraw International Edition
- 5) Design of Water Resources Systems, Arthur Mass, MacMillan 1962

Reference Books

- 6) Economics of Water Recourses Planning, L. D. James & R.R.Leo, McGraw Hills, NY 1971.
- 7) Water Resources Systems Engineering, W. A. Hill & J. A. Dracup.
- 8) Water shed Management – B.M. Tideman
- 9) Watershed management –J. V. S. MURTY, new Age International Publisher.
- 10)Integrated Watershed Management Perspectives and Problems - Beheim, E., Rajwar, G.S., Haigh, M., Krecek, J. (Eds.) , Springer Publication.
- 11)Managing Water in River Basins: Hydrology, Economics and Institutions -- M. Dinesh Kumar, Publisher: Oxford Universit Press
- 12)Water Resources Design Planning Engg and Economic; Edward Kuiper, Butterworth & Co.
- 13)ANN in Hydrology; Govinda Raju & Ramachandra Rao; PHI
- 14)Integrated Water Resources Management in Practice: Better Water Management for Development - R. L. Lenton, Mike Muller , Publisher Earthscan.
- 15)Sustainability of Integrated Water Resources Management - Editors: Setegn, Shimelis Gebriye, Donoso, Maria Concepcion (Eds.) Publisher Springer International Publishing .
- 16)Integrated Water Resources Management in the 21st Century: Revisiting the paradigm -Pedro Martinez-Santos, Maite M. Aldaya, M. Ramón Llamas, Publisher CRC Press, Taylor & Francis Group.
- 17)Key Concepts in Water Resource Management: A Review and Critical Evaluation - Jonathan Lautze, publisher Routledge.
- 18)Water Management – Jasapal Singh, M.S.Achrya, Arun Sharma – Himanshu Publication.

e - Resources

1. [nptel.iitm.ac.in/courses/webcourse-contents/IISc-Bang/water resource management.](http://nptel.iitm.ac.in/courses/webcourse-contents/IISc-Bang/water%20resource%20management)
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Elective II –(3) TQM and MIS in Civil Engineering

Teaching scheme

Lectures: 3 hours/week

Examination scheme

In semester exam: 30 marks---1 hour
End semester exam: 70 marks—2.5 hours

Unit I: Quality in Construction

(6 Hrs)

- Quality – Various definitions and interpretation. Importance of quality on a project in the context of global challenges.
- Factors affecting quality of construction, reasons for poor quality & measures to overcome.

Unit II: MIS

(6 Hrs)

- Introduction to Management Information systems (MIS) Overview, Definition.
- MIS and decision support systems, Information resources, Management subsystems of MIS.

Unit III: TQM & Defects in Construction

(6 Hrs)

- TQM – Necessity, advantages, Six sigma as a tool in TQM.
- Defects & its classification in construction. Measures to prevent and rectify defects.

Unit IV: TQM, ISO & Quality Manual

(6 Hrs)

- Difference between, quality control, quality assurance, total quality control and total quality management (TQM).
- Process based approach for achieving TQM. Study of ISO 9001 principles.
- Quality manual – Importance, contents, documentation. Importance of check-lists in achieving quality. Typical checklist for concreting activity, formwork activity, steel reinforcement activity.

Unit V: Management Control

(6 Hrs)

- Management information system structure based on management activity whether for Operational control, management control or strategic planning.
- Supply chain management as a tool in TQM, Benchmarking in TQM, Kaizen in TQM
- Categories of cost of Quality.

Unit VI: Modern tools in TQM Implementation

(6 Hrs)

- Development of an MIS for a construction organization associated with building works, study and use of various modules of ERP software for construction.
- Introduction to smart phone technology & incorporating GIS, GPS, Android subsystems for documentation and monitoring of construction projects.

**** Units IV, V & VI to be supplemented with case studies**

Text Books:

- Total Quality Management-- Dr. Gunmala Suri and Dr. Puja Chhabra Sharma—Biztantra
- Quality Control and Total Quality Management by P.L.Jain- Tata McGraw Hill Publ.Company
- Total Quality Management - Dr. S.Rajaram and Dr. M. Sivakumar-- Biztantra
- Total Engineering Quality Management – Sunil Sharma – Macmillan India Ltd.

Elective II (4)- Earthquake Engineering

Teaching scheme

Lectures: 3 hours/week

Examination scheme

In semester exam: 30 marks---1 hour

End semester exam: 70 marks—2.5 hours

Unit I

Introduction to earthquakes:

Geology of earth, configuration of tectonic plates in a globe, influence of Geology on earthquake, behavior of plates, their motion and effects, causes of earthquake and their Characteristics, Earthquake parameters, magnitudes, intensity, scales, classification of earthquake seismic zoning of India, seismic coefficients for different zones, .Lessons from past earthquake: - Study of damages caused due to past, earthquakes in/ outside India and remedial measures.

Unit II

Theory of vibrations:

Vibrations - definition, causes, classifications. Single Degree of Freedom systems (SDOF) - Free, forced, damped, un-damped vibrations with basic examples. Introduction to Multi-degrees of

Freedom systems (MDOF) - derivations of related equations and solutions to two degree and three degree of freedom systems.

Unit III

Seismic design of RC structure:

Introduction to IS1893 (Part-I): 2002, Seismic design Philosophy, provision, Seismic coefficient method. Response Spectra, Basic requirement, estimation of story shear, effect of unsymmetrical geometry and masses, mass center and stiffness center, estimation of story shear for symmetrical and torsion for unsymmetrical buildings. IS code provision to response spectrum.

Concept of ductile detailing, IS 13920 (1993) provisions for RC frame.

Unit IV

Seismic foundation design:

Type of forces generated due to earthquake, effects on different types of foundation, design of RCC isolated footing for earthquake loading, liquefaction, causes and its remedial measure.

Unit V

Introduction of different control systems: Passive control: base isolation and active control: bracing system, TMD etc and some latest invention.

Introduction to Disaster Management: Types of Disaster, Phases of disaster management, Disaster rescue, psychology and plan of rescue operations.

Unit VI

Strengthening and Retrofitting: Need of retrofitting, Evaluation of existing buildings, aging, weathering, development of cracks, improper load Path, asymmetry, materials and equipments for restoring and retrofitting, methodology of retrofitting for walls, slabs roofs columns, foundations etc. for buildings in stones, bricks, RCC.

Concept of shear wall,

Notes: Every design should confirm to latest versions of IS 1893, 4326, 13920, 13827,

13828, 13935

Text Books

1. Earthquake resistance design of structure by Duggal- Oxford University Press.
2. Earthquake – Resistant Design of Building Structures-Dr. Vinod Hosur-- Wiley India
- 3 Earthquake Tips NICEE, IIT, Kanpur
4. Elements of Earthquake Engineering by Jaikrishna and Chandarsekaran.

Reference Books

- 5 Dynamics of structure by Clough R.W. and Penzin J. McGraw Hill Civil Engineering Series
6. Dynamics of structure by Anil Chopra, Prentice Hall India Publication
7. Dynamics of structure by Mario Paz, CBSPD Publication
8. Geo-technical Earthquake Engineering by Kramer S. L. Prentice Hall India Publication
9. Introduction to Structural Dynamics by John M. Biggs
10. Mechanical Vibrations by V. P. Singh
11. Relevant Latest Revisions of IS codes.

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