JAMIA MILLIA ISLAMIA, NEW DELHI

SYLLABUS

MASTER OF TECHNOLOGY

EARTHQUAKE ENGINEERING

with effect from 2015-16

Department of Civil Engineering
Faculty of Engineering & Technology

SYLLABUS

MASTER OF TECHNOLOGY
EARTHQUAKE ENGINEERING

With effect from
2015 16

Department of Civil Engineering

Faculty of Engineering & Technology

Jamia Millia Islamia

New Delhi – 110025 (India)

http://www.jmi.ac.in/

PREFACE

Civil Engineering is the oldest branch in the engineering and technological field with its versatility in application. Earthquake Engineering is an important specialization in Civil Engineering as seismic analysis and design is essential component for the safe Civil Engineering structures. The M. Tech. in Earthquake Engineering program is one of the newest programs of the department and started in the year 2011. This specialized post graduate program is being offered by very few institutions of the country.

The human needs are being upgraded rapidly with time and new technology and products are being produced to meet the requirements. To keep the pace with time, the syllabus of M. Tech. (Earthquake Engineering) program is devised in the present form based on the suggestions of experts, academicians, persons working in the industry and researchers and on the feedback of the stakeholders. The latest trend in the industry and research field is combined with advanced knowledge of each subject while making the syllabus. The courses will help the students to make strong base for working in academic, research and industry environment.

The course consists of theoretical and laboratory components with seminar presentation and dissertation which will give the opportunity to the students to develop their skills in the field of Earthquake Engineering. The program consists of core course as well as elective courses. The elective courses are designed; provide the flexibility to students to choose on their choices. The latest softwares related to the various courses are available in the software laboratory to make the student abreast.

Prof. Mohd. Shakeel
Head,
Department of Civil Engineering
Faculty of Engineering &Techology,
JamiaMilliaIslamia, New Delhi 110025

New Delhi
3rd February, 2015

ABOUT THE UNIVERSITY

Jamia Millia Islamia, an institution originally established at Aligarh in United Provinces, India in 1920 became a Central University by an act of the Indian Parliament in 1988. In Urdu language, Jamia means 'University', and Millia means 'National'.

The story of its growth from a small institution in the pre-independence India to a central university located in New Delhi—offering integrated education from nursery to research in specialized areas—is a saga of dedication, conviction and vision of a people who worked against all odds and saw it growing step by step. They "built up the Jamia Millia stone by stone and sacrifice by sacrifice," said Sarojini Naidu, the nightingale of India.

Under the colonial British rule, two dominant trends joined hands and contributed towards in the birth of Jamia. One was the anti-colonial Islamic activism and the other was the pro-independence aspiration of the politically radical section of western educated Indian Muslim intelligentsia. In the political climate of 1920, the two trends gravitated together with Mahatma Gandhi as a catalyst. The anti-colonial activism signified by the Khilafat and the pro-independence aspirations symbolised by the non-cooperation movement of the Indian National Congress helped to harness creative energies and the subsequent making of Jamia Millia Islamia. Rabindranath Tagore called it "one of the most progressive educational institutions of India".

Responding to Gandhiji's call to boycott all educational institutions supported or run by the colonial regime, a group of nationalist teachers and students quit Aligarh Muslim University, protesting against its pro-British inclinations. The prominent members of this movement were Maulana Mehmud Hasan, Maulana Mohamed Ali, Hakim Ajmal Khan, Dr. Mukhtar Ahmad Ansari, and Abdul Majid Khwaja. Hakim Ajmal Khan, Dr. Mukhtar Ahmed Ansari and Abdul Majeed Khwaja supported by Gandhiji shifted Jamia from Aligarh to Karol Bagh, in New Delhi in 1925. In 1925, after long deliberation, a group of three friends studying in Germany—Dr. Zakir Husain, Dr. Abid Husain and Dr. Mohammad Mujeeb—decided to serve Jamia.

One of the first steps they took was the introduction of the hugely popular evening classes for adult education. This movement was later to become, in October 1938, an institution called Idara-i-Taleem-o-Taraqqi.

In 1928 Hakim Ajmal Khan passed away. That was the beginning of the second financial crisis, as it was Hakim Sahib himself who had been meeting most of Jamia's financial needs. The leadership of Jamia then moved into the hands of Dr. Zakir Husain, who became its Vice Chancellor in 1928. To resolve Jamia of these frequent crises, a group of young Jamia teachers, led by Dr. Zakir Husain, took a pledge to serve Jamia for the next twenty years on a salary not more than Rs. 150. This group was called the Life Members of Jamia. (History repeated in 1942 when a second group of Jamia teachers took a similar pledge).

Jamia's department of Printing and Publications was trifurcated in 1928 with the newly established Jamia Press at Darya Ganj, Urdu Academy, and Maktaba Jamia under the charge of Prof. Mohammad Mujeeb, Dr. Abid Husain and Mr. Hamid Ali respectively.

On 1 March 1935, the foundation stone for a school building was laid at Okhla, then a non-descript village in the southern outskirts of Delhi. In 1936, all institutions of Jamia, except Jamia Press, the Maktaba and the library, were shifted to the new campus. The basic emphasis of Jamia was on evolving innovative education methods. This led to the establishment of a teacher's college (Ustadon ka Madrasa) in 1938.

The fame of Jamia as an innovative education movement spread and dignitaries from foreign countries began visiting Jamia. Husein Raouf Bey (1933), Dr. Behadjet Wahbi of Cairo (1934), Ms. Halide Edib of Turkey (1936) were some of them. Foreigners, impressed by Jamia, began working in Jamia. The German lady Ms. Gerda Philipsborn (popularly known as Aapa Jaan) served Jamia for many years is buried in Jamia.

In 1939, Maulana Ubaidullah Sindhi (1872-1944), a theologian and freedom fighter, came to stay in Jamia on the invitation of Dr. Zakir Husain. He started a school of Islamic Studies in Jamia, called Baitul Hikmal, propagating the ideology of Shah Waliullah. Zakir Husain, later the President of India, recalled those days of indestructible optimism in the face of depravity 'when they had a longing to build and nothing to build with, as "days of joy".

After the attainment of Independence, Jamia continued to grow as an academic institution with a difference. Many foreign dignitaries made it a point to visit Jamia Millia Islamia during their visits to New Delhi. Among those who visited Jamia include Marshal Tito (1954), king Zahir Shah of Afghanistan (1955), crown prince Faisal of Saudi Arabia, king Reza Shah Pehlavi of Iran (1956) and prince Mukarram Jah (1960).

In 1962, the University Grants Commission declared the Jamia a 'deemed to be University'. Soon thereafter, the School of Social Work was established in 1967. In 1971, Jamia started the Zakir Husain Institute of Islamic Studies, to honour Dr. Zakir Husain, who had passed away in 1969. BE course in Civil Engineering commenced in 1978; in 1981, the faculties of Humanities and Languages, Natural Sciences, Social Science, and the State Resource Centre were founded. In 1983, it started the Mass Communication Research Centre and the Centre for Coaching and Career Planning. In 1985, it established the Faculty of Engineering & Technology and the University Computer Centre. Academic Staff College and the Academy of Third World Studies followed in 1987 and 1988.

By a Special Act of the Parliament, Jamia Millia Islamia was made a central university of India in December 1988.

At present Jamia has Nine faculties and a number of centres of learning and research, like AJK-Mass Communication Research Centre (MCRC), Academy of International Studies etc. The Jamia is also marching ahead in the field of Information Technology (IT). It offers various undergraduate and postgraduate IT courses. Apart from this, the Jamia has a campus wide network which connects a large number of its departments and offices.

ABOUT THE DEPARTMENT

The Department of Civil Engineering is one of the oldest and the largest department in the Faculty of Engineering & Technology. The department has produced several eminent engineers who have made important contributions in the planning and execution of many important Civil Engineering projects in India as well as abroad.

The Department offers two undergraduate courses in Civil Engineering. The Department also offers Master's programme with specialisations in Environmental Engineering and Earthquake Engineering .In all, there are around 560 students in undergraduate programme and 75 students pursuing their Masters degree. These courses are supported with strong doctoral programmes in all the major specialisations of Civil Engineering. More than 45 Ph. D. research scholars including many from foreign countries are currently working in the department on emerging research areas.

The Department is known for its reputed faculty with expertise in diverse fields. Presently, the department has 23 highly qualified, experienced, sincere and dedicated teaching faculty members, actively participating in research and consultancy work. During last 5 years, faculty members have published more than 280 papers in reputed refereed International Journals.

Over a period of time, the Department has built up a wide research potential. The research programmes of the department are funded by various agencies such as Ministry of Human Resource Development (MHRD), Department of Science & Technology (DST), Ministry of Environment & Forests (MoEF), Central Pollution Control Board (CPCB), All India Council of Technical Education (AICTE), University Grants Commission (UGC), Ministry of Steel and Ministry of Urban Development. Major area of research in the Department include; Sustainable Development, low cost sanitation, water treatment, air, noise and water quality modelling, Reuse of concrete, application of GIS and remote sensing in water resources and environment, Vulnerability assessment, Seismic analysis of structures, retrofitting, Soil structure interaction, Hydro-climatology, Water resource assessment and management.

The Department has established a state-of-the-art experimental facilities and laboratories in different fields of Civil Engineering. It has received the prestigious funding under FIST from DST and SAP from UGC. The Department has mobilized more than Rs 250 million from various external agencies to carry out research in cutting edge technologies in different fields of Civil Engineering.

The faculty also renders technical advice on live engineering problems to various Government and Private Sector companies throughout the country. These live projects are effectively used as training desk for our students at undergraduate and postgraduate levels. RITES, Military Engineering Services, Municipal Corporations of Delhi, Faridabad, Gurgaon, Ghaziabad, NOIDA, PWD, CPWD, DDA, HUDA, Jal Nigam etc. regularly hire services for technical advice and vetting of designs of infrastructure projects. The Department has generated around Rs 800 million through consultancies during the last five years.

International and national conferences, seminars and special lectures are a regular feature of the Department to impart education and training. The Department has active collaboration with academics and industry such as University of Applied Sciences Erfurt (Germany), Wessex Institute (UK), University of Waterloo (Canada), Asian Institute of Technology (Bangkok) and Steel Authority of India (INDIA).

Leading MNCs and public sectors are regular recruiter of our students and many students have been selected in Engineering Services. Several of our alumni pursued higher education in USA, UK, Germany, Canada, Australia and France and have been appointed as faculty members and consultants abroad.

The Department strongly believes in continuous efforts to strive for excellence by exploring new frontiers of knowledge, imparting the latest technical knowledge to the students and conducting high quality research.

INTRODUCTION

Civil Engineering plays a pioneering role for the development of the country. It began its journey from the beginning of the civilization, although no like its present shape. Developing country like India, we need continuous improvement of roads and infrastructure of support rapid industrialization. At the same time, more the industrialization, more the environmental side effects. The Department of Civil Engineering is one of the oldest departments of the Faculty of Engineering & Technology at Jamia Millia Islamia. The department also offering Ph.D. in different emerging field of Civil Engineering. Foreign students are also studying in the graduate, post graduate and Ph.D. programs. The department has loaded faculties, with educational qualifications from the top institutes in India as well as from abroad. They are actively engaged with teaching, research and consultancy in India and abroad.

The research works in the department of Civil Engineering supported by various funding organizations such as Ministry of Human Resource Development (MHRD), Department of Science & Technology (DST), Ministry of Environment & Forests (MoEF), Central Pollution Control Board (CPCB), All India Council of Technical Education (AICTE), University Grants Commission (UGC), Ministry of Steel and Ministry of Urban Development.

The major research areas of the faculty members are: Reuse of demolished concrete, application of GIS and remote sensing, Vulnerability assessment, Seismic analysis of structures, retrofitting, Soil structure interaction, Finite element method, Computation methods, Smart materials and structures, functionally graded materials and structures etc.

The important laboratories of the department are: materials, structures, concrete, surveying, environmental and hydraulics laboratory. The laboratories are equipped with some latest and modern equipments. Some laboratories were upgraded under FIST financially assisted by DST and SAP from UGC. The faculty also renders technical advice on live projects from RITES, Military Engineering Services, Municipal Corporations of Delhi, Faridabad, Gurgaon, Ghaziabad, NOIDA, PWD, CPWD, DDA, HUDA, Jal Nigam etc. The department is very active in conducting workshops, seminars and conferences collaboration with academics and industries such as University of Applied Sciences Erfurt (Germany), Wessex Institute (UK), University of Waterloo (Canada), Asian Institute of Technology (Bangkok) and Steel Authority of India

(INDIA) on regular basis to impart education and training, and sharing the knowledge and research development with others. The private, public sectors and MNCs recruit our students in their organization every year. Many of our students qualify all India Examination such as GATE, Engineering services etc. and go to abroad viz. USA, UK, Germany, Canada, Australia and France for higher studies; jobs in research, academics, consultancies and industries.

Some of the major instruments used for M. Tech. (Earthquake Engineering) laboratory are: ABEM instrument Terraloc Mark 6 in Seismology laboratory, Horizontal Shake Table with eccentric cam and 12 Experimental models in Dynamics laboratory. In Software laboratory, the students use MATLAB and other finite element software to analyze some problems related to finite element and earthquake engineering.

The department is consistently giving efforts to provide the quality education to the students with latest knowledge and technology of research and industry with the services of equipped laboratory and highly skilled teacher.

PROGRAMME EDUCATIONAL OBJECTIVES (PEO'S)

AND

PROGRAMME OUTCOMES (PO'S)

M. Tech in Earthquake Engineering Program is a unique program being offered by Civil Engineering Department. The PEOs describe the career and professional accomplishments. The PEOs of the program are as follows:

1. The graduates will engage in the technical education of Earthquake Engineering across a range of application areas including analysis and design of earthquake resistant structures, computational methods etc.
2. The graduates will experience successful careers and provide leadership and will have an ability to continuously adapt to meet the challenges of a changing environment.
3. The graduates will be well prepared for pursuing further studies in India and abroad as well.
4. The graduates will be groomed to serve the society and country by making new products, technology and software.
5. The graduates will be prepared to lead the academic, research organizations and consultancies.

The following are the Programme Outcomes **(PO'S)**.

1. Ability to apply knowledge of mathematics, science, and engineering to solve the problems related to Earthquake Engineering.
2. Ability to design and conduct experiments of structural dynamics and seismology, to solve the engineering problems many latest softwares, and analyze the experimental data.
3. Ability to design earthquake resistant structures considering safety, efficiency, elegance and economy
4. Ability to work in engineering and non-engineering multidisciplinary teams to complete an assigned project.
5. Ability to identify, formulate with mathematical modelling, and solve the engineering problems using different computational tools and perform laboratory experiments (if required).

6. Ability to understand professional and social responsibility and understand the impacts of engineering solution on the society, environment, country, and on universe as well.

7. Communicate efficiently in their profession and career with team members, colleagues and with the society at large orally, in writing and presentation.

8. Identify new problems for research, solution and application of the problems, ability to update the latest knowledge in research and industry, ability to go for higher studies and research organization and in the consultancy.

9. Apply the knowledge to study latest events of earthquake and adopt new methodology for analysis and earthquake resistant design of structures with latest architecture and materials.

10. Apply the knowledge to run the latest software related to analysis and design of structures, develop new software in this field including new techniques, tools and practices.

PROGRAMME STRUCTURE

M. TECH. (Earthquake Engineering)

Semester-I

Course No.	Course Title	Cr.	Period Per Week			Marks			Remarks
			L	T	P	Sessional	Theory	Practical	
MEQ-101	Advanced Mathematics	4	3	1	--	40	60	---	CBCS
MEQ-102	Theory of Vibrations	4	3	1	--	40	60	---	Core Course
MEQ-103	Advanced Structural Analysis	4	3	1	--	40	60	---	Core Course
MEQ-104	Finite Element Method	4	3	1	--	40	60	---	AECC
MEQ-105	Seismology and Geotechnical Earthquake Engineering	4	3	1	--	40	60	---	Core Course
MEQ-150	Seismology Laboratory	2	--	--	4	30	--	20	Core Course
Total		**22**	**15**	**5**	**4**	**230**	**300**	**20**	
			Total Hrs		24	550			

Semester-II

Course No.	Course Title	Cr.	Period Per Week			Marks			Remarks
			L	T	P	Sessional	Theory	Practical	
MEQ-201	RCC Design	4	3	1	--	40	60	---	Core Course
MEQ -202	Fundamental of Earthquake Analysis	4	3	1	--	40	60	---	Core Course
MEQ -203	Analysis and Design of Tall Buildings	4	3	1	--	40	60	---	Core Course
MEQ -204	Structural Optimization	4	3	1	--	40	60	---	Core Course
MEQ -205	Reliability Based Design	4	3	1	--	40	60	---	CBCS
MEQ-250	Structural Dynamics Laboratory	2	--	--	4	30	--	20	Core Course
Total		**22**	**15**	**5**	**4**	**230**	**300**	**20**	
			Total Hrs		24	550			

Semester-III

Course No.	Course Title	Cr.	Period Per Week			Marks			Remarks
			L	T	P	Sessional	Theory	Practical	
MEQ-301	Computational Methods and Software Applications	4	3	1	--	40	60	---	SEC
MEQ-302	Offshore Structures	4	3	1	--	40	60	---	Core Course
MEQ-303	Earthquake Resistant Design	4	3	1	--	40	60	---	Core Course
MEQ-350	Dissertation	6	--	3	6	90	--	60	Core Course
MEQ-360	Seminar	2	--	--	4	30	--	20	Core Course
Total		**20**	**9**	**6**	**10**	**240**	**180**	**80**	
			Total Hrs		25	500			

Semester-IV

Course No.	Course Title	Cr.	Period Per Week			Marks			Remarks
			L	T	P	Sessional	Theory	Practical	
MEQ-401	Disaster Mitigation and Management	4	3	1	--	40	60	---	CBCS
MEQ-450	Dissertation	12	--	6	12	180	--	120	Core Course
Total		**16**	**3**	**7**	**12**	**220**	**60**	**120**	
			Total Hrs		22	400			

	1st Semester	2nd Semester	3rd Semester	4th Semester
Compulsory	--	--	--	--
Core Course	14	18	16	12
CBCS	4	4	--	4
SEC	--	--	4	--
AECC	4	--	--	--
Total	**22**	**22**	**20**	**16**

SEMESTER-I

Advanced Mathematics

Paper Code	**MEQ -101**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- This course is structured in order to provide insight knowledge about the application of mathematics in engineering practices

Course Learning Outcome

- Will be able to apply Laplace and Fourier Transform for solving engineering problem
- Will be able to apply the concept of envelope of a family of curves and interpolation for solving engineering problem
- Will be able to apply Numerical integration for solving engineering problem

Course Description

UNIT – I

Application of Laplace transforms and I.L.T. in the particular solution of integral equations and integro-differential equations, Z-transforms and its applications in the solution of linear difference equations, Use of DeMoiver's theorem, Ferrari/Descarte method, Cardan's method, reciprocal-equation method in the general solution of higher order ordinary linear differential equations with constant and variable coefficients, Use of Euler – Poisson Equations in Calculus of Variations (i.e. external of functional), Isoperimetric problems.

UNIT – II

Infinite Fourier transforms, infinite Fourier sine and cosine transforms and its applications, Fourier-Legendre series, Fourier-Bessel series, Product solution of Laplace equations, heat conduction equations, wave equations, Poisson's equations by the method of separation of variables and its applications in boundary value problems, General solution of homogeneous and non-homogeneous linear partial differential equations of higher order with constant and variable coefficients.

UNIT - III

Envelope of a family of curves, Evolute of a curve, Geometrical representation of $W = f(z)$,

Conformal mapping, Problems on Tensor analysis, Properties of eigen values of square matrices of order 4, 5 and 6, and complex matrices, Numerical solution of boundary value problems using finite difference and cubic spline methods, Numerical solution of heat conduction equations, Poisson, Laplace and wave equations.

UNIT – IV

Interpolation, Aitken and Aitken-Nevilie methods, Missing-terms problems, Hermite interpolation, Fitting of a curve in given sub-interval using cubic spline interpolation, Representation of a tabulated function in powers of (x – a) using Newton's divided difference formula, Applications of numerical successive differentiation in practical problems and double interpolation.

UNIT – V

Numerical integration using Romberg method, Gauss-Legendra and Lobatto methods, Gaussian integration and numerical double integration; Conversion of a differential equation into integral equation and vice versa, Solutioins of Fredholm and Volterra integral equations of first and second kinds; Numerical solution of a system of non-linear equations using Newton-Raphson method; Solution of system of linear equations in four variables using Gauss-Jorden and Crout's methods.

Text Books

- Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern India Ltd.
- Higher Engineering Mathematics, B.S. Grewal, Khanna Publishers.
- Introductory Methods of Numerical Analysis, S.S. Sastry, Prentice Hall of India (PHI)

Reference Books

- Numerical Methods for Scientific and Engineering Computation, Jain, Iyengar, New Age International Pvt. Ltd.
- Advanced Engineering Mathematics, by Jain, Iyengar and Jain, New age International Pvt. Ltd.

Software or other Requirement

- MATLAB
- MS EXCEL

Theory of Vibrations

Paper Code	**MEQ-102**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- To impart fundamentals of structural dynamics to M.Tech students in Earthquake Engineering.
- To teach them solution techniques used for solving dynamic problems.
- To prepare them for understanding seismic analysis of structures offered in the subsequent semester.
- To offer them the ability to think and handle real life dynamic problems.

Course Learning Outcome

- Will acquire knowledge of the fundamentals of structural dynamics.
- Will be able to pursue advanced level courses in dynamics and in related application areas.
- Will be able to handle real life dynamic problems.

Course Description

Unit-I

Sources of dynamic loading, concepts of oscillation and SHM, inertia force, restoring force, damping force, modeling of damping, free and forced vibration of SDOF, determination of damping co-efficient

Unit-II

Solution of equation of motion of SDOF in time & frequency domains for irregular loading, FRF, transient dynamics, support motions

Unit-III

Equations of motion of MDOF system, generation of stiffness matrix for dynamic d.o.f, eigen-value problem, mode shapes & frequencies, support motions, solution for irregular loading in time and frequency domain

Unit-IV

Normal mode theory, mode acceleration approach, solution using FFT and IFFT, FRF, solution for irregular support motion, modal response spectrum analysis

Unit-V

Continuum system, Rayleigh's method for approx frequency calculation, normal mode analysis, wave propagation analysis

Text Books

- Dynamics of Structures; R.W. Clough and J. Penzien; McGraw Hill (Student Edition)
- Dynamics of Structures: Application to Earthquake Engineering; Prentice Hall (Student Edition)
- Theory of Vibration with Application; W.T. Thomson; Prentice Hall

Reference Books

- Dynamics of Structures, Hurtey, W.C. and Rubinstein, M.F.; Prentice Hall
- Structural Dynamics for Structural Engineers, Hart, G.C., Wong, K.K.F., and Wong, K.; John Wiley
- Siesmic Analysis of Structures; Datta, T.K.; John Wiley

Advanced Structural Analysis

Paper Code	**MEQ -103**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- To make clear understanding for idealization of various structural forms and supports to carry different loadings
- To make the students understand basic methods of structural analysis of framed structures, Plates and Shells to interpret the results obtained from software analyses.
- To perform manual analysis of structures and compare them with those obtained from software

Course Learning Outcome

- Will be able to Idealize structures and their supporting system
- Will have clear understanding of the response of the structures under different loadings
- Will be able perform analysis of structures confidently

Course Description

Unit-I

Methods of Structural Analysis, Structural idealization, Types of Framed Structures, Deformations in Framed Structures, Actions and Displacements, Static and Kinematic Indeterminacy, Actions and Displacement Equations, Flexibility and Stiffness Matrices, Equivalent Joint Loads, Energy Concepts and Virtual Work

Unit-II

Flexibility Method, Temperature Changes, Pre strains, Support Displacements, Joint Displacements, Member End Actions, Support Reactions, Formalization of Flexibility Method

Unit-III

Stiffness Method, Temperature Changes, Pre strains, Support Displacements, Joint Displacements, Formalization of Stiffness Method, Direct Stiffness Method, Formation of Joint Stiffness Matrix, Formation of Load Vector, Rotation of Axes in Two Dimensions, Rotation Matrix, Rotation Transformation Matrix, Rotation of Axes in Three Dimensions, Rectangular Framing, Use of Symmetry and Anti-symmetry, Loads Between Joints and Transfer Matrix, Oblique Supports and Elastic Supports, Member Stiffnesses and Fixed End Actions from Flexibilities, Non prismatic and Curved Members, Discontinuities in Members, Shearing Deformations

Unit-IV

Plastic Analysis, Introduction, Elastic Analysis versus Plastic Analysis, Ultimate Moment, Newton Raphson's Technique Plastic response of a Simple Beam, Ultimate Strength of Fixed and Continuous Beams, Rectangular Portal Frames, Plastic Hinge under Distributed Loads, Frames with Inclined Members, Effect of Axial Load and Shear on Plastic Moment Capacity, Nonlinear Analysis, Geometric Stiffness Matrix, Modified Newton Raphson's Technique

Unit-V

Thin and Thick Plates, Kirchoff-Love Plate Theory of Thin Plates, Navier's and Levi's Solutions, Numerical and Approximate Methods, Deformations of Shells without Bending

Text Books

- Matrix Analysis of Framed Structures, William Weaver Jr. and James M. Gere, CBS Publidhers
- Structural Analysis, A. Ghali and A. m. Neville, E & FN SPON

Reference Books

- Analysis and Behaviour of Structures, Rossow, G.C, Prentice Hall
- Analysis of Structural Systems, Fleming, J. F., Prentice Hall

Software or other Requirement

- STAAD PRO
- ETAB

FINITE ELEMENT METHOD

Paper Code	**MEQ- 104**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- Develop the finite element equations to model engineering problems
- Apply finite element method to formulate and solve structural problems
- Solve differential equations using the approximate numerical methods

Course Learning Outcome

- Students will be able to use concept of science, engineering and mechanics in the subject
- Students will be able to use the concept of the subject for using FEM softwares
- Students will be able to identify, formulate and solve engineering problems applying FEM

Course Description

Unit-I

Introduction to Finite Element Analysis, Introduction to Elasticity, Finite Element Formulation Techniques: Virtual Work and Variational Principle, Galerkin Method; Finite Element Method: Displacement Approach, Stiffness Matrix and Boundary Conditions

Unit- II

Element Properties: Natural Coordinates, Triangular, Rectangular Lagrange, Serendipity and Solid Elements; Isoparametric Formulation; Numerical Integration: One, Two and Three Dimensional

Unit- III

Analysis of Frame Structures: Stiffness and Analysis of Truss and Beam Members; Analysis of Continuous Beam, Plane Frame, Grid and Space Frame

Unit- IV

FEM for Two and Three Dimensional Solids: Constant Strain Triangle, Linear Strain Triangle, Rectangular Elements, Numerical Evaluation of Element Stiffness, Computation of Stresses, Geometric Nonlinearity and Static Condensation; Finite Element Formulation of Axisymmetric Element; Finite Element Formulation for 3 Dimensional Elements

Unit- V

FEM for Plates and Shells: Introduction to Plate Bending Problems, Finite Element Analysis of Thin, Thick

Plate and Skew Plate; Introduction to Finite Strip Method; Finite Element Analysis of Shell; Finite Elements for Elastic Stability, Fluid Mechanics and Dynamic Analysis

Text Books

- Finite Elements and Approximation, Zienkiewicz, O. C. and Morgan, K., John Wiley & Sons
- Finite Element Method, Reddy, J.N., McGraw-Hill Book Company
- Finite Element Procedures, Bathe, K. J., PHI Learning

Reference Books

- A Unified Approach to the Finite Element Method and Error Analysis Procedures, Dow, J.O., Elsevier.
- Concepts and Applications of Finite Element Method, Cook, R.D., Malkus, D., Plesha, M. and Witt, J., John Wiley & Sons

Software or other Requirement

- ANSYS
- ABAQUS
- MATLAB, STAAD PRO

Seismology and Geotechnical Earthquake Engineering

Paper Code	**MEQ-105**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- Provide the students with an introduction of seismology and advanced level understanding of the mechanisms of earthquakes and measurement of strong ground motions
- Enable the students to conduct ground response analysis
- Provide the students with advanced level understanding of dynamic soil properties and soil-structure interaction
- Enable the students to perform seismic slope stability analysis/design
- To study the seismological activity of the earth in response to sub-surface strata
- Micro-zonation analysis of different earthquake zones in India.

Course Learning Outcome

- Have advanced understanding of seismology, including plate tectonics, faults, waves induced by earthquakes, and size of earthquakes
- Be able to use strong ground motion data in earthquake engineering analysis/design
- Be able to perform site response analysis
- Be able to evaluate liquefaction resistance and assess liquefaction potential using field data
- Be able to perform seismic slope stability analysis
- Be able to design retaining walls with consideration of seismic load

Course Description

Unit-I

Introduction to the hazards of earthquakes: strong ground motions, tsunamis, landslides, liquefaction.

Review of plate tectonics. Seismic hazard in Puerto Rico and beyond; Maths review: Fourier Transforms

Single degree of freedom dynamics, damped vibrations. Convolutions, Green's Functions; A seismic station: sensors and data loggers. Poles and zeros for sensor response; Mechanical and digital sensor design and performance

Unit-II

Interpretation of Seismic Records - acceleration, velocity and displacement; Issues with strong ground motions and record parameterisation; Theory of wave propagation: Body waves Theory of wave propagation: Surface waves

Unit-III

Dynamic Soil Properties: Stress & strain conditions, concept of stress path; Measurement of seismic response of soil at low and high strain, using laboratory tests; Cyclic triaxial, cyclic direct simple shear, resonant column, shaking table, centrifuge and using field tests - standard penetration test, dynamic plate load test, block vibration test, SASW/MASW tests, cross bore hole; Evaluation of damping and elastic coefficients; Stress-strain behavior of cyclically loaded soils; Effect of strain level on the dynamic soil properties; Equivalent linear and cyclic nonlinear models; Static and dynamic characteristics of soils.

Unit-IV

Background and lessons learnt from damages in past earthquake; Wave in infinite & semi-infinite media –one, two and three dimensional wave propagation; Attenuation of stress waves – material and radiation damping; Dispersion, wave in a layered media; Determination of Dynamic Soil Properties as per IS-5249; Ground Response Analysis: Introduction one, two and three dimensional analyses; Introduction to soil-structure interaction

Unit-V

Evaluation of liquefaction potential: characterization of earthquake loading and liquefaction resistance, cycle stress ratio, Seed and Idress method; Effects liquefaction; Seismic design of retaining walls: types, modes of failure, static pressure, seismic response (including M-O method), seismic displacement, design consideration; Types of earthquake induced landslides; Evaluation of slope stability: stability analysis with dynamic loading, friction circle method, effective and total stress methods of analysis, yield acceleration, damage potential, displacement analysis, effect of saturated and submerged conditions, FEM analysis of slope stability

Text Books

- International Handbook of Earthquake and Engineering Seismology. Lee, W.H.K, Kanamori, H., Jennings, P.C., Kissinger, C., Academic Press
- Introduction to Seismology. Shearer, P. M., Cambridge University Press
- Geotechnical Earthquake Engineering. Kramer, S. L., Prentice Hall
- Soil Dynamics, Prakash, S., McGraw Hill Book Company.

Reference Books

- An Introduction to Seismology, Earthquakes and Earth Structure. Stein, S. and Wysession, M., Blackwell Publishing
- Modern Global Seismology. Lay, T., and Wallace, T. C., Academic Press
- Geotechnical Earthquake Engineering Handbook, Day Robert, W., McGraw-Hill.

SEMESTER-II

RCC Design

Paper Code	**MEQ – 201**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- To provide basic concepts, behaviour and design of various reinforced concrete structures
- To introduce IS code provisions of reinforced concrete design and reinforced detailing
- To introduce ductility requirement of design and detailing
- To introduce yield line analysis of slabs and pre-stressed concrete

Course Learning Outcome

- Students will have the understanding of basic concepts, behaviour and design of various reinforced concrete structures
- Students will be conversant with various IS code provisions of reinforced concrete design and reinforced detailing
- Students can assess the ductility requirement of design and detailing
- Students will be well aware about yield line analysis of slabs and prestressed concrete

Course Description

Unit-I

Introduction, Design Concepts, Design Methods, Characteristic strength and load; Reinforcement Concrete Materials; Cement, Aggregates, Water, Admixture, Pozzolana, Concrete, Plastic Concrete, Hardened Concrete, Concrete Mix Design; Design of reinforced concrete structural elements under–Flexure, Shear, Torsion, and Bond; Serviceability requirements

Unit-II

Design of slabs; One way slab, Two way slab, Flat slab and Waffle slab; Yield Line Analysis of slab

Unit-III

Design of Columns; Design of Column section under axial load, axial load and uni-axial moment, axial load and bi-axial moments; Design of short and slender column elements; Ductile reinforcement detailing of column

Unit-IV

Prestressed concrete and design of prestressed concrete structural elements

Text Books

- RCC Design, S.N. Sinha, Tata MacGraw Hill
- Design of RCC, Pillai and Menon, Tata MacGraw Hill
- Design of Prestressed Concrete, Krishna Raju, Tata MacGraw Hill

Reference Books

IS Codes:

- IS 456: 2002
- SP:16 and SP:32
- IS 13920: 1993

Software or other Requirement

- Name of relevant software's ETAB, SAP and ANSYS
- Monograms if any
- Reports if any

Fundamentals of Earthquake Analysis

Paper Code	**MEQ -202**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- To impart the knowledge of structural dynamics (taught in the previous semester) for the analysis of structures for earthquake excitation.
- To understand the analysis of structures for different kinds of seismic excitation namely, time history records, FFT, power spectral density function and response spectrum.
- To acquaint the student with the frequency domain, time domain and non linear analyses including ductility.

Course Learning Outcome

- The students will learn available techniques for earthquake analysis of structures.
- The students will be able to use standard softwares for the seismic analysis of structures.
- Students will be able to model a structure for seismic analysis using right type of input and also, will be able to physically understand the results of the analysis.

Course Description

Unit-I

Seismology including seismic hazard analysis, various types of seismic inputs- time history, fourier spectrum, power spectral density function, design response spectrum, attenuation relationship

Unit-II

Analysis of structures for specified ground motion, time history analysis, frequency domain analysis, cases of multi supports excitation, modal analysis and mode acceleration approach

Unit-III

Spectral analysis of structures for random ground motion, case of single point excitation and multi point excitation, response analysis for partially correlated ground motion, modal spectral analysis

Unit-IV

Response spectrum method analysis for structures, single point excitation and multi points excitation, base shear approach, response spectrums provided in different codes and their critical appraisal

Unit-V

Inelastic response analysis of structure for earthquake, cases of single degree and multi degree freedom system, pushover analysis, concept of ductility, inelastic spectrum and ductility behaviour of tall buildings

Text Books
• A. K. Chopra, Structural Dynamics for Earthquake, Prentice Hall • T. K. Datta, Seismic Analysis of Structures, John Wiley

Reference Books
• R.W. Clough and J. Penzien, Dynamics of Structures, McGraw Hill International

Software or other Requirement
• STAAD PRO • ETAB

Analysis and Design of Tall Buildings

Paper Code	**MEQ - 203**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- To familiarize students with the recent developments in seismic analysis and design of tall buildings from the perspective of efficient use in design offices leading to latest research in this area like prescriptive design methods and modern performance-based design methods for tall buildings
- Understand common structural systems utilized in tall buildings and their design philosophy.
- Perform preliminary design and analysis of various structural systems for tall buildings.

Course Learning Outcome

- Develop analytical models for tall buildings using latest structural analysis programs, and to assess structural response under seismic excitation using such analytical tools.
- Effectively participate in structural design of tall buildings for specified performance objectives at component and system levels.

Course Description

Unit-I

Structural system and concept; Approximate methods for analysis of multistoried frames; Analysis of symmetric frames, mass irregularities in plane and elevation; Analysis for torsions in buildings

Unit-II

Design of building with shear walls and coupled walls; Effect of openings; Design specifications and I.S. codes

Unit-III

Behavior of framed tube systems, tube in tube system and blended tube system; Simplified analytical models for symmetrical tubular structures

Unit-IV

Design of Raft and Pile Foundations

Text Books

- Tall Building Structures: Analysis and Design, Bryan Stafford Smith & Alex Coull, Wiley India Pvt. Ltd.
- Foundation Engineering, P.C. Varghese, PHL Learning Private Limited.
- High Rising Building Structures, Wolfgang Schueller, Robert E. Krieger Publishing Company.
- Reinforced Concrete Structures, Arthur, H.N., McGraw-Hill.

Reference Books

- Structural Analysis and Design of Tall Buildings: Steel and Composite Construction, Bungale S. Taranath, CRC Press
- Structural Analysis, A. Ghali and A.M. Neville, E & FN SPON
- The Seismic Design Handbook, Farzad Naeim, Kluwer Academic Publishers.
- Handbook of Concrete Engineering Author:- Mark Fintel, Publication:- CBS Publications & Distributors.

Software or other Requirement

- Name of relevant software's 1. STAAD, ETAB, SAP and ANSYS
- Monograms if any
- Reports if any

Structural Optimization

Paper Code	**MEQ -204**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- To make clear understanding of various Optimization Techniques and Optimality Criteria.
- To apply different optimization techniques for solving structural engineering problems

Course Learning Outcome

- Will be able to optimize structures and their supporting system
- Will have clear understanding of basic methods of Optimization
- Will be able to understand the Specialized Optimizations techniques

Course Description

Unit-I

Introduction and Basic Concepts: Historical Development, Engineering applications of Optimization, Art of Modeling, Objective function, Constraints and Constraint surface, Formulation of design problems as mathematical programming problems, Classification of optimization problems, Optimization techniques, Problem formulation from Structural Engineering

Unit-II

Optimization using Calculus: Functions of single and two variables, Optimization of Functions of Multiple Variables with Unconstrained Optimization, Optimization of Functions of Multiple Variables subject to equality constraints, Optimization of Functions of Multiple Variables subject to inequality constraints, Examples from Structural Engineering

Unit-III

Linear Programming: Standard form of linear programming (LP) problem, Canonical form of LP problem, Graphical method, simplex method, Revised simplex method, Dual Simplex method, other algorithms for solving LP problems;

Nonlinear Programming: Nonlinear Programming with equality and inequality constraints;

Structural applications

Unit-IV

Dynamic Programming: Sequential optimization, Representation of multistage decision process, Types of multistage decision problems, Concept of sub optimization and the principle of optimality, Recursive equations, Computational procedure, Discrete versus continuous dynamic programming

Integer Programming: Integer linear programming, Concept of cutting plane method, Mixed integer programming, Solution algorithms

Examples from Structural Engineering

Unit-V

Advanced topics in Optimization: Multi-objective optimization; Multi-level optimization; Genetic Algorithm, Use of Fuzzy Logic and ANN in optimization, Applications in Structural Engineering.

Text Books

- *Engineering Optimisation – Theory and Practice*, S. S., New Age International, Rao
- *Optimisation for Engineering Design – Algorithms and examples,* Deb, K., Prentice Hall

Reference Books

- *Optimum Structural Design,* Kirsch U., McGraw Hill.
- *Introduction to Optimum Design*, Arora J S. McGraw Hil

Software or other Requirement

- MATLAB

Reliability Based Design

Paper Code	**MEQ – 205**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- To teach the fundamentals of reliability & design philosophy and significance of reliability in structural design
- To train students for various probabilistic and stochastic theorems as well as models applicable to reliability structures.
- To teach various reliability methods for feuding out reliability index and system reliability

Course Learning Outcome

- Students will have the understanding of fundamentals of reliability and importance of reliability in structural design
- Students will be conversant with various probabilistic and stochastic process/models applicable to structural reliability
- Students can assess the reliability index and system reliability

Course Description

Unit-I

Nature of Structural Design and Safety: Evolution of design codes; Hazards, risks and economy of structural design, Uncertainty Modeling: Probability theory, random variables, probability distributions, moments, extreme value statistics, utility and descriptive statistics; Fuzzy set theory

Unit-II

Bayesian Decision Theory: A priori and posteriori probability; Bayes strategy and computation, Statistical Inference: Model estimation, hypothesis testing, confidence intervals and significance testing

Unit-III

Stochastic Models for Material Strengths: Classic strength models - ideal brittle material, idea plastic material, fiber bundle; Fatigue - damage accumulation laws, cycle counting, damage statistics; Bogdanoff's cumulative

damage model. Stochastic Models for Loads: Gust wind loads, wave loads, earthquake loads, traffic load and live load modeling; Stochastic theory of load combinations

Unit-IV

Reliability Methods: Multiple safety factor formats; Characteristic values; Reliability index and system reliability; code calibrations

Text Books

- Ang , A.H., S. and Tang, W.H.. "Probability Concepts in Engineering Planning and Design, Vol. I & II., John Wiley & Sons
- Blockley , D.I.. "The Nature of Structural Design and Safety", Ellis Horwood
- Augusti, G., Baratta, A. and Casciati, F., "Probabilistic Methods in Structural Engineering, Chapman & Hall

Reference Books

- Chernoff, H. and Moses, L.E., "Elementary Decision Theory", Dover Publications
- Elishakoff, I.., "Probabilistic Theory of Structures", 2nd edition, Dover Publications

Software or other Requirement

- Name of relevant software's ETAB, SAP and ANSYS
- Monograms if any
- Reports if any

SEMESTER-III

Computational Methods and Software Applications

Paper Code	**MEQ -301**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- To teach various methods to solve simultaneous algebraic equations
- To impart the significance of eigenvalues and eigenvectors and solution of such problems.
- To teach regression analysis and introduce AI and Neural Network applications.
- To train on MTALAB/ OCTAVE and their applications in solving engineering problems.

Course Learning Outcome

On completion of the Course, students will be able to

- Solve simultaneous algebraic equations
- Solve Eigen value and Eigen vector problems
- Carry out regression analysis and Neural Network applications
- Use MATLAB/OCTAVE for solving engineering problems

Course Description

UNIT - I

Approximation and Errors - Significant figures, Accuracy and Precision, Types of error, General error formula and Convergence.

Solution of simultaneous algebraic equations

Direct method - Gauss elimination method, Pivoting strategies, ill-conditioned systems, Matrix Inversion method, Matrix factorization, LU decomposition, Doolittle, Crout Decomposition; Special Matrices - Banded matrices, Tridiagonal system; Cholesky Decomposition. **Iterative methods** - Gauss Seidel and Jacobi methods, Convergence of iteration methods.

Eigen values and Eigen vectors, Power method, Orthogonal matrices. Hotelling's method, Householder's method.

MATLAB/Octave applications

UNIT – II

Differential Equations:

Solution of **ODE**, Initial value problem, Taylor's series, Euler method, Runge Kutta Methods, Boundary value problems. **Finite Difference methods**.

Partial Differential equations – Elliptic equation, Laplace equation, Parabolic equation, *Crank-Nicolson method.*

MATLAB/Octave applications

UNIT - III

Regression Modelling, covariance and the correlation coefficient, Linear regression models, estimation of parameters in regression models**. Inference with regression models** - Hypothesis Testing in multiple regression, Test for significance, confidence intervals. Prediction of new observations and model adequacy.

Goodness-of-fit measures, Adjusted R^2.
MATLAB/Octave applications

UNIT – IV
AI and ML, Data and its processing, **Neural Network**, Network Architecture, Activation function, Supervised and unsupervised learning, **Convolutional Neural Network**.
Neural Network applications

UNIT – V
Introduction to **MATLAB**/OCTAVE programming**, Language fundamentals** – Matrices, Expressions, entering commands, Indexing, Arrays, Mathematics- Matrices in the MATLAB/OCTAVE, simultaneous equations, Factorization, eigenvalues, Multivariate data, data analysis.

Graphics – Basic plotting functions, Mesh and surface plots, display and printing graphics.

Programming – control and script functions, Application of MATLAB/OCTAVE.

Text Books

- S.C. Chapra and R.P. Canale, "Numerical Methods for Engineers", 7th Ed (2015) or latest. McGraw Hill
- S.C. Chapra, "Applied Numerical Methods with MATLAB® for Engineers and Scientists", 4th Edition (2018), or latest, McGraw Hill
- D.C. Montgomery and G.C. Runger, "Applied Statistics and Probability for Engineers", 3rd Edition (2003), or latest, John Wiley & Sons,
- Mathwoks (2020) "MATLAB Primer, the Math Works

Reference Books

- R.L. Burden, J. D. Faires, A.M. Burde, "Numerical Analysis", Tenth Edition (2016) or latest, Cengage Learning
- T.R. Young and M. J. Mohlenkamp (2020) Introduction to Numerical Methods and Matlab Programming for Engineers,
- Richard L. Burden, J. Douglas Faires, Annette M. Burden, (2016 or latest) "Numerical Analysis", 10th Edition Cengage Learning
- Jain and Iyengar Numerical Methods for Scientific and Engineering Computation, New Age International Pvt. Ltd.
- https://www.geeksforgeeks.org/machine-learning/#mp

Software or other Requirement

- MATLAB
- Neural Network Toolbox of MATLAB
- OCTAVE
- PYTHON

Offshore Structures

Paper Code	**MEQ-302**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- To have a sound knowledge of offshore structures.
- To study different wave theories for understanding sea characteristics.
- To study wind and wave forces in offshore environment.
- To acquire fundamental understanding of behavior of different kinds of offshore platforms under sea environment.

Course Learning Outcome

- After doing the course, candidate should posses a sound knowledge of offshore structures.
- Candidate should understand different wave theories for understanding sea characteristics.
- Candidate should understand to compute wind and wave forces in offshore environment.
- Candidate should understand fundamental behavior of different kinds of offshore platforms under sea environment.

Course Description

Unit-I

Introduction, Design of Fixed Offshore Structures, Examples of Fixed Offshore Structures, Analysis of Fixed Offshore Structures, Ocean Surface Waves, Wave Theories; Airy, Cnoidal and Stokes.

Unit-II

Environmental Loadings: Wind Speeds, Wind Forces, Wave Forces on Vertical Piles, Wave Forces on Arbitrarily Oriented Cylinders, Maximum Wave Force on an Offshore Structure, Joint Loads from Wave Forces, Buoyant Forces, Current Loadings, Additional Environmental Loadings.

Unit-III

Static Methods of Analysis, Design Environmental Conditions, Frame Analysis of Steel Offshore Structures, Bending Stress Amplification, Pressure induced stresses in steel structures, Design stress criteria for steel members.

Unit-IV

Analysis of Offshore Concrete Platforms, Pressure Induced Stresses in Concrete Structures; Effects of End Restraints, Spherical End Caps, Examination for Dynamic Effects, Dynamics of Structures, Lumped Description of Wave Forces.

Unit-V

Foundation Analysis: Soil Characteristics, Piles for Template Structures, Prediction of Axial Pile Capacity, Elastic response of Pile to Axial Loading, Footings for Offshore Structures, Bearing Capacity of Footings, Resistance of Footings to Sliding, Design of Footings subjected to General Loading Conditions.

Text Books
• Offshore Structural Engineering, Thomas H Dawson, Prentice-Hall, INC. • Handbook of offshore engineering, S. K. Chakarbarti, Vol. 1&2, Elsevier Science.

Reference Books and Software
• Wave forces on offshore structures, Turgut Sarpkaya, Cambridge University Press. • Dynamics of Offshore Structures, Minoo H. Patel, Butterworth & Co. Ltd.

Software or other Requirement
• SACS software for Fixed Platform's Design

Earthquake Resistant Design

Paper Code	**MEQ -303**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- To impart the knowledge of required seismic input for earthquake resistant design, in particular response spectrum given in code.
- To acquaint the students with seismic design philosophy of structures (concrete, steel and masonry) consistent with code provisions and practices.
- To make the students aware of the seismic behavior of different structural components and accordingly use fundamentals of flexural and combined flexural cum shear design for the elements.

Course Learning Outcome

- The students will be able to effectively analyse and design the structures for seismic forces.
- Students will be able to understand ductile design and detailing of joints.
- Students would learn important code provisions for the seismic design of structures and would understand properly the basis of the code provisions.

Course Description

Unit-I

Concept of earthquake resistant design of reinforced concrete buildings: earthquake and vibration effect on structures - basic elements of earthquake resistant design, identification of seismic damages from past earthquakes, effect of structural irregularities on the performance buildings during earthquake, seismo-resistant building architecture

Unit-II

Seismic analysis and modeling of reinforced concrete buildings: procedure for seismic analysis as per IS codes, consideration of infill walls in seismic analysis, mathematical modeling of multi-storeyed RC buildings; Earthquake resistant design of reinforced concrete buildings: ductility consideration in earthquake resistant design, earthquake resistant design based on IS codes, design of shear wall, capacity based design

Unit-III

Steel buildings: seismic behavior of steel, steel frames, flexural members, connections design and joint behavior, steel panel zones, bracing members, ductile design of frame members;

Non-structural elements: failure mechanism, analysis, prevention of damages, isolation of elements

Unit-IV

Earthquake resistant design of masonry buildings: identification of damages and non-damages in masonry

buildings from past earthquakes, elastic properties of structural masonry, lateral load analysis of masonry building, design of masonry buildings based on IS codes;
Earthquake resistant design of timber buildings: connections, lateral load transfer and construction

Text Books

- Seismic Design of Reinforced Concrete and Masonry Buildings, Pauley, T. and Priestley, M.J.N, John-Wiley & Sons
- Elements of Earthquake Engg. and Structural Dynamics, Andre Filiatrault, Overseas Press India Pvt. Ltd.
- Earthquake Resistant Design of Structures, Pankaj Aggarwal and Manish Shrikhande, Prentice Hall of India Ltd

Reference Books

- Reinforced Masonry Design, Schneider, R.R. and Dickey, W.L, 3nd Ed., Prentice Hall
- Concrete Structure in earthquake regions, Edmund Booth, Design & Analysis" Longman Scientific & Technical

Software or other Requirement

- STAAD PRO
- ETAB

SEMESTER-IV

Disaster Mitigation and Management

Paper Code	**MEQ -401**	**(Lectures-Tutorial-Practical)/Week**	**(3-1-0)**
Credits	**4**	**Course Marks (Mid-End-Total)**	**(40-60-100)**

Course Objectives

- To impart the knowledge of natural and manmade disasters
- To acquaint the students with effect of natural and manmade disasters
- To make the students aware of the disaster mitigation and management

Course Learning Outcome

- The students will be able to understand types of disasters and its effects
- Students will be able to understand disaster management at national and international level
- Students would learn about disaster mitigation, repair, restoration and strengthening of existing buildings, seismic evaluation, methods of retrofitting etc

Course Description

Unit –I

Definition of disaster and its relationship with human development, types of disaster, global disaster perspective, causes and effects of various types of disasters, engineering and technical aspects of disasters, environmental aspects of disasters, urban disasters, climate change

Unit –II

Disaster management, Impact of disasters, human rights in disaster management, disaster and government's response, responding to disasters, hunger and disaster, general observation

Unit –III

Hazard and risk assessment for earthquake, land slide, flood, cyclone, fire and chemical hazard; Methods of hazard evaluation and procedure for risk evaluation for multi-hazard scenario

Unit –IV

Pre and post-disaster mitigation for infrastructure and civil amenities: methods of seismic evaluation, seismic test methods, response control concepts

Unit – V

Pre and post-disaster mitigation for infrastructure and civil amenities: seismic retrofitting strategies –

reinforced concrete buildings, masonry buildings, steel buildings and timber buildings

Text Books

- Earthquake-Resistant Design of Structures, Second Edition, Shashikant K. Duggal, Oxford University Press
- Earthquake-Resistant Design of Structures, Pankaj Agarwal, Manish Shrikhande, PHI Learning Private Limited, New Delhi, India

Reference Books

- Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.
- Carter, W. Nick, 1991: Disaster Management, Asian Development Bank, Manila.
- Central Water Commission, 1987, Flood Atlas Of India, Cwc, New Delhi.
- Central Water Commission, 1989, Manual Of Flood Forecasting, New Delhi.
- Government Of India, 1997, Vulnerability Atlas Of India, New Delhi.
- Sahni, Pardeep Et.Al. (Eds.) 2002, Disaster Mitigation Experiences and Reflections. Prentice Hall Of India, New Delhi.

Software or other Requirement

- MS Office
- Internet