Master of Technology in Earthquake Engineering
National Centre for Disaster Mitigation and Management
(Revised Scheme July 2021)

Code	Course Title	Type	Credit (L-T-P)
Semester 1			
21EQT 503	1. Earthquake Structural Dynamics	PC	4(3 1 0)
21EQT 502	2. Earthquake Resistant Design of Steel Structures	PC	3(3 0 0)
21EQT 501	3. Earthquake Design Concepts	PC	3(3 0 0)
21EQP 801	4. *Earthquake Dynamics Laboratory*	PE	2(0 0 4)
21EQT 809	5. *Seismology & Geotechnical Earthquake Engineering*	PE	3(3 0 0)
21EQT 803	6. *Computational Methods*	PE	3(3 0 0)
		Total Semester Credits	18
Semester 2			
21EQT 504	1. Earthquake Analysis of Structures	PC	3(3 0 0)
21EQT 505	2. Earthquake Resistant Design of Masonry Structures	PC	3(3 0 0)
21EQT 506	3. Finite Element Methods	PC	3(3 0 0)
21EQT 810	**4.** *Soil Structure Interaction*	PE	3(3 0 0)
21EQT 803	**5.** *Ductile Design of RC Structures*	PE	3(3 0 0)
21CET545	6. *Plate & Shell*	OE	3(3 0 0)
		Total Semester Credits	18
		Total course Credits (I & II Semester)	**36**
***Maximum one Open Elective is allowed in both the semester put together.**			
Semester 3			
EQS 701	Research Project		4(0 0 16)
EQD 703	Dissertation & Thesis		8(0 0 16)
		Total Third Semester Credits	12
Semester 4			
EQD 704	Dissertation/Thesis		12(0 0 24)
		Total Fourth Semester Credits	12
		Total Credits (III & IV Semester)	24
		Total Program Credits (all four semester)	**60**

Note: Fraction of the any of the courses can be handled either through Experts from Industry or Academia or through MOOCS as per the PG Regulation after due approval from the DPGC

List of Program Electives			
EQT 6xx	1. Earthquake Dynamics Laboratory		2(0 0 4)
EQT 6xx	2. Nonlinear analysis of Structures		3(3 0 0)
EQT 6xx	3. Ductile Design of RC Structures		3(3 0 0)
EQT 6xx	4. Earthquake Retrofitting of Structures		3(3 0 0)
EQT 6xx	5. Earthquake Geotechnical Engineering		3(3 0 0)
EQT 6xx	6. Structural Control		3(3 0 0)
21EQT 809	7. Seismology& Geotechnical Earthquake Engineering		3(3 0 0)
EQT 6xx	8. Plates & Shells		3(3 0 0)
21EQT 803	9. Computational Methods		3(3 0 0)
21EQT 810	10. Soil Structure Interaction		3(3 0 0)
EQT 6xx	11. Stability Analysis of Structures		3(3 0 0)
EQT 6xx	12. Theory of Elasticity		

Syllabus of Program Core

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title: **Earthquake Structural Dynamics**
Credit: 4	L-T-P: 4-0-0
Version:	Approved on:
Pre-requisite course: Structural Analysis	

COURSE CONTENT:

Sources of Dynamic Loading, Concept of SHM, Inertia force, Damping Force, Damped and Un-damped free vibrations of a SDoF System, Forced Vibration of SDoF Systems- Harmonic Loading, Periodic Loading, Irregular loading.

Frequency Domain Analysis using FFT, Time Domain Analysis using Numerical Techniques, Response due to transient loading using Duhamel's Integral, Response of SDoF due to motion of support, Transmissibility, State Space Solution in Frequency and Time Domain.

MDoF Systems, Equations of Motion for Single Support and Multi Support Excitation, Frequencies and Mode Shapes, Use of Raleigh-Ritz Method for approximate analysis of Mode Shapes and Frequencies, Normal Mode Theory, Direct and Modal Analysis in Time and Frequency Domains.

Equation of Motion for Continuum, Frequencies and Mode Shapes Solution in Time and Frequency Domain using Normal Mode Theory

REFERENCES

1. Chopra, A.K. (1970). *Dynamics of Structures*, Prentice Hall, 3rd Edition, NY.
2. Clough, R.W. and Penzien, J. (1993). *Dynamics of Structures*, McGraw Hill.
3. Humar, J.L. (1990). *Dynamics of Structures*, Prentice Hall.
4. Mario, P. (1995). *Structural Dynamics*, CBS Publ. New Delhi.
5. Timoshenko, S. (1948). *Advanced Dynamics*, McGraw Hill Book Co, NY.
6. Meirovitch, L. (1986). *Elements of Vibration Analysis*, 2nd Edition, McGraw Hill International Edition, Singapore.
7. Biggs, J.M. (1964). *Introduction of Structural Dynamics*, McGraw Hill, NY.

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title: **Earthquake Resistant Design of Steel Structures**
Credit: 3	L-T-P: 3-0-0
Version:	Approved on:
Pre-requisite course: Basic Steel Design	

COURSE CONTENT:

Properties of Steel, Ductility Control, Basic Design Philosophy, Ground Motion Response Spectra, Methods of Analysis, Methods of Design, Material Ductility, Section Ductility, Member Ductility, Methods of Ductility Design.

Design of Tension Members, Compression Members, Beams, Beam-Columns, Plate Girders, Connections, Plastic Methods of Analysis.

Stability, Flexural Behaviour of Beams, Torsion, Lateral Torsional Buckling of Beams, Continuous Beams, Combined Bending and Axial Forces, Behaviour of Bracing Systems, Design of a Ductile Frames.

REFERENCES

1. Gaylord E. H. Jr., Gaylord C. N. and Stallmeyer J. E. (1992). *Design of Steel Structures*, Tata McGraw Hill Publication.
2. Englekirk, R. (2003). *Steel Structures: Controlling Behaviour Through Design*, John Wiley & Sons.
3. Salmon, C. G. and Johnson, J. E. (1980). *Steel Structures: Design and Behaviour*, Harper & Row Publishers, New York.
4. Bruneau, M., Uang, C.M. and Whittaker, A. (1998). *Ductile Design of Steel Structures*, McGraw Hill, New York.
5. Mazzolani, F.M. and Piluso, V. (1996). *Theory and Design of Seismic Resistant Steel Frames*, E&FN Spon.
6. V. Gionncu and Mazzolani, F. M. (2002). *Ductility of Seismic Resistant Steel Structures*, SPON Press.

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title: **Earthquake Design Concepts**
Credit: 3	L-T-P: 3-0-0
Version:	Approved on:

Pre-requisite course: Structural Analysis

COURSE CONTENT:

Dynamic actions on buildings wind versus earthquake. Basic Aspects of Seismic Design, Four Virtues of Earthquake Resistant Buildings- Seismic Structural Configuration, Structural Stiffness, Strength and Ductility. Earthquake Demand versus Earthquake Capacity. Force-based Design to Displacement-based Design. Seismic Design Force. Dynamic Characteristics of Buildings, Ground Motion Characteristics. Earthquake Capacity of Buildings – Elastic Behaviour, Earthquake Capacity of Buildings – Inelastic Behaviour, Distribution of Damage in Buildings, The Open Ground Storey Buildings, Strong Column - Weak Beam Design Strength Hierarchy, Structural Plan Density, Ductility, Earthquake-Resistant Design Methods

REFERENCES

1. Ambrose,J., and Vergun,D. (1999). *Design for Earthquakes*, John Wiley & Son, Inc., USA.
2. Arnold,C., and Reitherman,R. (1982). *Building Configuration and Seismic Design*, John Wiley & Sons, Inc., NY, USA
3. Bachmann,H. (2003). *Seismic Conceptual Design of Buildings – Basic principles for engineers, architects, building owners, and authorities*, BBL Vertrieb Publikationen, Bern.
4. Dowrick,D.J. (1987). *Earthquake Resistant Design for Engineers and Architects*, 2nd Ed., John Willey & Sons, NY, USA.
5. IS: 13920 (1993). *Indian Standard Code of Practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces*, Bureau of Indian Standards, New Delhi.
6. IS: 1893 (Part 1) (2007). *Indian Standard Criteria for Earthquake Resistant Design of Structures*, Bureau of Indian Standards, New Delhi.
7. IS: 456 (2000). *Indian Standard Code of Practice for Plain and Reinforced Concrete*, Bureau of Indian Standards, New Delhi.
8. CSI (2010). *Structural Analysis Program (SAP) 2000*, Version 14, Computers and Structures Inc., USA.

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title: **Earthquake Analysis of Structures**
Credit: 3	L-T-P: 3-0-0
Version:	Approved on:
Pre-requisite course: Structural Dynamics	

COURSE CONTENT:

Seismic inputs- time histories of ground motions, Fourier spectrum, power spectral density function, response spectrums, energy spectrums, design response spectrum, site specific spectrum, simulation of artificial time histories of ground motion ; Analysis of SDOF and MDOF systems for specified ground motion in time and frequency domain-special case of multi support excitation ; Spectral analysis of structures for random ground motion-special case of multi support excitation ; Response spectrum method of analysis-its extension for multi support excitation, code provisions for different countries ; Inelastic seismic response analysis including concept of ductility and inelastic response spectrum, push over analysis ; Brief introduction to dynamic soil-structure interaction.

REFERENCES

1. Chopra, A.K. (2004). *Dynamics of Structures*, Prentice Hall India, New Delhi.
2. Clough, R.W. and Penzien, J. (1993). *Dynamics of Structures*, McGraw Hill.
3. Datta, T.K. (2010). *Seismic Analysis of Structures*, John Wiley & Sons (Asia), Singapore.

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title: **Earthquake Resistant Design of Masonry Structures**
Credit: 3	L-T-P: 3-0-0
Version:	Approved on:
Pre-requisite course: Structural Analysis	

COURSE CONTENT:

Behaviour of Masonry Structures During Past Earthquakes: Common modes of failure, effect of unit shapes and mortar type, effect of roof and floor systems; Common deficiencies.

Material Properties: Masonry units- stones, brick and concrete blocks, hollow and solid units; Manufacturing process; Mortar, grout and reinforcement; Various tests and standards.

Masonry Under Compression: Prism strength, Failure mechanism, types of construction and bonds; Eccentric loading; Slenderness – effective length and effective height, effect of openings; Code provisions.

Masonry Under Lateral Loads: In-plane and out-of-plane loads, bending parallel and perpendicular to bed joints; Shear and flexure behaviour of piers; Test and standards; Analysis of perforated shear walls, lateral force distribution for flexible and rigid diaphragms; Arching action; Combined axial and bending actions.

Earthquake Resistant Measures: Analysis for earthquake forces, role of floor and roof diaphragm; Concept and design of bands, bandages, splints and ties; Reinforced masonry; Vertical reinforcement at corners and jambs; Measures in random-rubble masonry; Confined masonry; Code provisions.

Masonry Infills: Effect of masonry infills on seismic behaviour of framed buildings; Failure modes; Simulation of infills – FEM and equivalent strut; Safety of infills in in-plane action – shear, compression and buckling; Out-off plane action, arching; Code provisions.

REFERENCES

1. Drysdale, R. G., Hamid, A. H. and Baker, L. R. (1994). *Masonry Structure: Behaviour and Design*, Prentice Hall, Englewood Cliffs.
2. Schneider, R.R. and Dickey, W. L. (1994). *Reinforced Masonry Design*, 3rd Ed, Prentice Hall. 1994
3. Paulay, T. and Priestley, M. J. N. (1995). *Seismic Design of Reinforced Concrete and masonry Buildings*, John Wiley & Sons.
4. Hendry, A. W. (1998). *Structural Masonry*, Macmillan Press Ltd.
5. FEMA 356 (2000). *Prestandard and Commentry For The Seismic Rehabilitation of Buildings*, Federal Emergency Management Agency, Washington, D.C.9.
6. Tomazevic, M. (2000). *Earthquake Resistant Design of Masonry Buildings*, Imperial Colleges Press. 2000
7. Donald Anderson and Svetlana Brzev (2009). *Seismic Design Guide for Masonry Buildings*, Canadian Concrete Masonry Producers Association.

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title: **Finite Element Method**
Credit: 3	L-T-P: 3-0-0
Version:	Approved on:
Pre-requisite course:	

COURSE CONTENT:

Finite element technique, discretization, energy and variational approaches. Basic theory, displacement and force models, slope function theory, use of parametric and local coordinates, convergence criteria, numerical integration.

Applications, plane stress and plain strain problems, axi-symmetric solids, three dimensional problems, plate and shell structures, temperature problems.

Nonlinear problems, introduction to iterative and incremental procedures for material and geometrically nonlinear problems, examples from plane stress and stability. Applications to Civil Engineering problems.

REFERENCES

1. Bathe, K.J. (2002). *Finite Element Procedures*, Prentice Hall.
2. Reddy, J. N. (1982). *Finite Element Method*, John Willey & Sons.
3. Hughes, T .R. J. (2000). *Finite Element Method*, Dover Publication.

Syllabus of Program Electives

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title: **Earthquake Dynamics Laboratory**
Credit: 2	L-T-P: 0-0-3
Version:	Approved on:
Pre-requisite course:	

COURSE CONTENT:

1. Dynamics of a three storied building frame subjected to harmonic base motion
2. Dynamics of a one-storied building frame with planar asymmetry subjected to harmonic base
3. Dynamics of a three storied building frame subjected to periodic (non- harmonic) base
4. Vibration isolation of a secondary system.
5. Dynamics of a vibration absorber.
6. Dynamics of a four storied building frame with and without an open ground floor.
7. Dynamics of one-span and two-span beams.
8. Earthquake induced waves in rectangular water tanks.
9. Dynamics of free-standing rigid bodies under base motions.
10. Seismic wave amplification, liquefaction and soil-structure interactions.

REFERENCES

1. Chopra, A.K. (2004). *Dynamics of Structures*, Prentice Hall India, New Delhi.
2. Mario, P. (1995). *Structural Dynamics*, CBS Publ. New Delhi.

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title: **Nonlinear Analysis of Structures**
Credit: 3	L-T-P: 3-0-0
Version:	Approved on:
Pre-requisite course: Structural Analysis	

COURSE CONTENT:

Review of displacement method of analysis; Concept of stiffness matrix of structure; Element stiffness matrix; Transformation matrix; Direct generation of stiffness matrix; Beams & frames; Code number approach; Generation of stiffness matrix by assembling process; Matrix force method of analysis.

Introduction to inelastic analysis of structures; Geometric & material nonlinearity; Tangent & secant method of analysis; Incremental analysis.

Elastoplastic analysis of multistory frames; Elements of plastic analysis; Upper & lower bound theorem; Mechanism method of analysis; Plastic analysis of multistory frames.

Concept of stability analysis using spring & rigid links; Equilibrium approach & energy approach; Energy approach for stability analysis of beams & columns; Classical stability analysis of frames using stability charts; Stability analysis of frames using FEM.

REFERENCES

1. Kanchi, M.B. (1999). *Matrix Methods of Structural Analysis*, John Wiley & Sons.
2. Baker, L. and Heyman, J. (1980). *Plastic Design of Frames*, Cambridge University Press.
3. Weaver, J.M. and Gere, W. (1990). *Matrix Analysis of Framed Structures*, Van Nostrand Reinhold, NY.

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title: **Ductile Design of RC Structures**
Credit: 3	L-T-P: 3-0-0
Version:	Approved on:
Pre-requisite course: Structural Analysis	

COURSE CONTENT:

Introduction to RC Structures-Need for ductility in structures: earthquake, impact and blast resistant designs, Nonlinear Design Philosophies , Earthquake-resistant design philosophy - contribution to ductility by four virtues, Blast resistant design philosophy - concept of structure toughness.

Methods of Design, WSD, LSD, ULD, LRFD; Review of LSD - flexure, axial-flexure, shear, torsion, Capacity Design Concept, Confinement of concrete, concept of over-strength, Flexure design, shear design, strong-column weak-beam philosophy.

Beam-column Joints, Loading, effects under seismic loading, beam bar anchorage, shear design

Collapse Mechanisms-Levels of ductility (section, member and structure ductilities), Modeling non-linear response of structural components and systems, Demand-capacity ratios: incremental DCRs and pushover analysis, Storey and sway mechanisms

Special Systems and Structures- Dual systems: design of RC walls, Large sections: design of bridge piers

REFERENCES

1. Paulay, T. and Priestley, M.J.N. (1992). *Seismic Design of Reinforced Concrete and Masonry Buildings*, John Wiley & Sons, Inc
2. Penelis, G.G. and Kappos, A.J. (1997). *Earthquake-resistant Concrete Structures*, E & FN Spon
3. Priestley, M.J.N., Seible, F, and Calvi, G.M. (1996). *Seismic Design and Retrofit of Bridges*, John Wiley & Sons, Inc
4. Murty, C.V.R., Goswami, R., Viajanarayanan, A.R., and Mehta, V.V. (2012). *Some Concepts in Earthquake Behaviour of Buildings*, Gujarat State Disaster management Authority
5. Naeim, F. (Ed.) (2001). *The Seismic Design Handbook*, Kluwer Academic Publishers, Boston
6. Eibl, J. (1988). *Concrete Structures under Impact and Impulsive Loading*, Bulletin d' Information No. 187, Comité Euro-International du Béton (CEB), Lausanne
7. Kassimali, A. *Matrix Analysis of Structures*, Brooks/Cole Publishing Company, USA, 1999
8. Codes and Standards of India, US, Japan, New Zealand, EU.

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title: **Earthquake Retrofitting of Structures**
Credit: 3	L-T-P: 3-0-0
Version:	Approved on:
Pre-requisite course: Structural Dynamics	

COURSE CONTENT:

Damage Detection Techniques- Rapid Visual Technique, By Classical Testing, Non-Destructive Testing, Ambient Vibration Technique, Forced Vibration Techniques; Assessment of the Existing Structure from the experimental Data.

Concept of Retrofitting, Rehabilitation and Strengthening of Structures- Classical Techniques like strengthening by adding Structural Features, Strengthening of Beams and Columns, Use of FRP.

Seismic Base Isolation- Fundamentals of Base Isolation, Design of Isolators, Design of Base Isolated building using UBC,

Use of other Passive Control Devices:: VEDs, TMDs, Steel Yielding Joints and other energy absorbing devices.

Performance Evaluation of Retrofitted Structures, Retrofitting of Bridges/ Strength Evaluation of Piers and use of base Isolation.

REFERENCES:

1. Soisson, H. E. (1975). *Instrumentation in Industry*, John Willey & Sons, NY.
2. BoomField, J.P. (1997). *Corrosion of Steel in Concrete*, E & FN SPON.
3. Ganesan, T.P. (2000). *Modal Analysis of Structures*, University Press.
4. IS: 13925 (1993). *Repair and Seismic Strengthening of Buildings-Guidelines*, Bureau of Indian Standard, New Delhi, 1993.
5. SP 25 (1984). *Causes and Prevention of Cracks in Buildings*, Bureau of Indian Standard, New Delhi, 1984.
6. BSSC (2000). *FEMA 356: Pre-Standard and Commentary for the Seismic Rehabilitation of Buildings*, Building Seismic Safety Council, Washington, D.C., U.S.A.
7. Naeim, F. (Ed.) (2001). *The Seismic Design Handbook*, Kluwer Academic Publishers, Boston, USA.
8. Priestley, M.J.N., Seible, F., and Calvi, G.M. (1996). *Seismic Design and Retrofit of Bridges*, John Wiley & Sons Inc, USA.

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title: **Earthquake Geotechnical Engineering**
Credit: 3	L-T-P: 3-0-0
Version:	Approved on:

Pre-requisite course: Geotechnical Earthquake Engineering

COURSE CONTENT:

Measurement of Dynamic Soil Properties: Field tests: Reflection test, Refraction test, SASW test, Cross-hole test; Laboratory test: Resonant column test, Bender element test, Cyclic shear and triaxial test; Dilatancy of sand subjected to cyclic drained shear; Dilatancy under cyclic loading.

Features of liquefaction induced damages; Mechanism of onset of liquefaction; Assessment of liquefaction potential; Behaviour of soil undergoing cyclic undrained loading; In-situ tests on liquefaction potential of subsoils; Post-liquefaction behaviour of liquefied ground; Prediction of permanent displacement due to liquefaction; Mitigation of liquefaction induced damage.

Two/Three dimensional ground response analysis: Dynamic finite element analysis; equivalent finite element approach; Nonlinear finite element approach.

Seismic Slope Stability: Earthquake induced landslides; Evaluation of slope stability: Static and seismic slope stability analysis.

Seismic Design of Retaining Walls: Types of retaining wall failures; Static pressure on retaining walls; Seismic pressure on retaining walls; Seismic design considerations.

Soil Improvement for Seismic Hazard Remediation: Densification techniques; Reinforcement techniques; Drainage techniques; Verification of soil improvement.

REFERENCES:

1. Kramer, S.L. (1996). *Geotechnical Earthquake Engineering*, Prentice Hall International, Upper Saddle River, NJ.
2. Towhata, I. (2008). *Geotechnical Earthquake Engineering*, Springer-Verlag Berlin Heidelberg.
3. Prakash, S. (1981). *Soil Dynamics*, McGraw Hill Book Company, USA.
4. Srbulov, M. (2011). *Practical Soil Dynamics*, Springer, Dordrecht Heidelberg London New York.

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title**: Structural Control**
Credit: 3	L-T-P: 3-0-0
Version:	Approved on:

Pre-requisite course: Structural Dynamics

COURSE CONTENT:

Fundamentals of Control Theory- state space equation, Laplace transforms, bodes diagram, phase plots, FRF, Feedbacks, gain matrix, PID controller, feedback and feed forward control, pole placement technique, observers, Ackerman's formula ; Concepts of Structural control, Passive Control- base isolation, TMDs, VEDs , shape memory alloy, deformed joints, TLDs and TLCDs ; Active Control- LQR control, modal control using pole placement technique, effect of time delay, observed and unobserved control, control theory using Lyapunov stability condition, instantaneous control ; Brief introduction to Semi Active Control.

REFERENCES:

1. Modern Control Engineering by Katsuhico Ogata, Prentice Hall
2. Active Structural Control- Theory and Practice by T.T.Soong, Longman Scientific and Technical
3. Seismic Analysis of Structures by T.K.Datta, John Wiley

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code:	Course Title: **Seismology & Geotechnical Earthquake Engineering**
Credit: 3	L-T-P: 3-0-0
Version:	Approved on:
Pre-requisite course: Basic Geotechnical Engineering	

COURSE CONTENT:

Introduction of Engineering Seismology; Reid's elastic rebound theory; Internal structure of earth; Theory of plate tectonics; Plate margins and earthquake occurrence; Seismic Waves: Body waves and Surface waves; Earthquake Size: Intensity, Magnitude; Local site effects; Seismicity of India.

Strong motion measurement: Seismographs, Data acquisition and digitization, strong motion records; Ground motion parameters; Estimation of ground motion parameters.

Introduction of seismic hazard analysis; Identification and evaluation of earthquake sources; Deterministic seismic hazard analysis; Probabilistic seismic hazard analysis.

Waves in unbounded media: One dimensional wave propagation, three dimensional wave propagation; Waves in a semi-infinite body: Rayleigh waves, Love waves; Attenuation of stress waves: Material and radiation damping.

One dimensional ground response analysis: Linear approach, nonlinear approach; Ground response analysis for layered soil profile; Comparison of one-dimensional ground response analyses; Illustration of soil-structure interaction.

Stress-strain behaviour of cyclically loaded soils: Equivalent linear model, cyclic nonlinear model; Hyperbolic and Ramberg-Osgood stress-strain models; Strength of Cyclically loaded soils: Definition of failure, cyclic strength, monotonic strength.

REFERENCES

1. Kramer, S.L. (1996). *Geotechnical Earthquake Engineering*, Prentice Hall International, Upper Saddle River, NJ.
2. Prakash, S. (1981). *Soil Dynamics*, McGraw Hill Book Company, USA.
3. Towhata, I. (2008). *Geotechnical Earthquake Engineering*, Springer-Verlag Berlin Heidelberg.
4. Lowrie, W. (2011). *Fundamentals of Geophysics*, Cambridge University Press, Cambridge.

UG/PG : PG	**Department:** National Centre for Disaster Mitigation and Management
Course Code: EQT	**Course Name:** Plates and Shells
Credit: 3	**L-T-P:** 3-0-0
Version: 2021	**Approved on:**
Pre-requisite course:	

COURSE CONTENT:

Plate equation and behaviour of thin plates in Cartesian, polar and skew coordinates; Curvilinear coordinates and coordinate transformation; Isotropic and orthotropic plates, bending and twisting of plates; Numerical solutions. Shell behaviour, shell surfaces and characteristics, classifications of shells, equilibrium equations in curvilinear coordinates, force displacement relations; Membrane analysis of shells of revolution and cylindrical shells under different loads, shallow shells, membrane solution of elliptic paraboloids and hyperboloids, solutions of typical problems.

Books:

1. Timoshenko, S.P. and Woinowsky-Kreiger, S., "*Theory of Plates and Shells*", McGraw-Hill Inc.
2. Ventsel, E. and Krauthammer, T., "*Thin Plates and Shells*", CRC Press
3. Krishna Raju, N., "*Advanced Reinforced Concrete Design*", CBS Publishers and Distributors Pvt. Ltd.
4. Varghese, P.C., "*Design of Reinforced Concrete Shells and Folded Plates*", PHI
5. Ugural, Ansel C., "*Plates and Shells: Theory and Analysis*", CRC Press.

UG/PG : PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code: EQT	**Course Name:** Computational Methods
Credit: 3	**L-T-P:** 3-0-0
Version: 2021	**Approved on:**
Pre-requisite course:	

COURSE CONTENT:

Solution of Equations and Eigenvalue Problems:
Taylor's series, Mclaurin series, Error analysis; roots of nonlinear equations, solutions of a large system of linear equations and Eigenvalue problem of a matrix; Pascal's triangle for one and two dimensions, divided differences; Newton's forward and backward difference formulas; Differentiation using interpolation formulae; Numerical integration by trapezoidal and Simpson's rules; Romberg's method; Two and Three point Gaussian quadrature formulae. Symbolic MATLAB® and complex numbers.

Interpolation and Approximation:
Solution of the equation; Fixed point iteration: x=g(x) method; Newton's method; Solution of linear system by Gaussian elimination and Gauss-Jordon method; Iterative method-Gauss Seidel method, Inverse of a matrix by Gauss Jordon method; Eigenvalue of a matrix by power method and by Jacobi method for symmetric matrix.
Numerical Differentiation and Integration: Advanced numerical linear algebra and related numerical methods; Direct and iterative methods for linear systems; Decompositions and SVD factorizations; stability and accuracy of numerical algorithms.

Linear / Non-Linear IVP AND BVP:
Laplace, Poisson, harmonic, bi-harmonic equations, Nonlinear ordinary differential equations, and partial differential equations; Nonlinear optimization, Novel technique for solving geometrical and material nonlinear problems, and wavelet analysis.

Books:

1. Kreyszig, E., "*Advanced Engineering Mathematics (10/e)*", Wiley publications.
2. Hildebrand, F.B., "*Introduction to Numerical Analysis*", Dover publications.
3. Chapra, S.C. and Canale, R.P., "*Numerical Methods for Engineers (5/e)*", Tata McGraw-Hill.

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code: EQT	**Course Name:** Soil Structure Interaction
Credit: 3	**L-T-P:** 3-0-0
Version: 2021	**Approved on:**
Pre-requisite course:	

COURSE CONTENT:

Introduction: Overview of Soil-Structure Interaction, Soil-Structure System Behaviour, Equations for Shallow Foundation Stiffness and Damping,
Impedance of Vertical Pile Foundations: Impedance of Single Piles, Impedance of Grouped Piles & Discrete Element Methods (*p-y* and *t-z* Curves).
Nonlinear Soil-Structure Interaction Models for Response History
Analysis: Nonlinear Structure and Equivalent-Linear Soil, Nonlinearity in the Foundation and Soil
Kinematic Interaction: Shallow Foundations at the Ground Surface, Embedded Shallow Foundations, Pile Foundations
Modeling of Structure: Continuous models, discrete models and finite element models.
Implementation: Force-Based Procedures, Displacement-Based Procedures, Response History Procedures. Low-rise residential buildings, multistory buildings, bridges, dams, nuclear power plants, offshore structures, Soil-pile-structure interactions.

References:

1. Wolf, J. P., "*Dynamic Soil-Structure Interaction*", Prentice Hall
2. Wolf, J. P., "*Soil-Structure Interaction in the Time-Domain*", Prentice Hall
3. Wolf, J. P. and Song, C., "*Finite Element Modelling of Unbounded Media*", John Wiley & Sons
4. Chowdhury, I. and Dasgupta, S.P., "*Dynamics of Structure and Foundation - A Unified Approach : Fundamentals*", CRC Press
5. Chowdhury, I. and Dasgupta, S.P., "*Dynamics of Structure and Foundation - A Unified Approach: Applications*", CRC Press
6. Bull, J.W., "*Soil-Structure Interaction: Numerical Analysis and Modelling*", CRC Press
7. Kolář, V. and Němec, I., "*Modelling of Soil-Structure Interaction*", Elsevier

UG/PG: PG	Department/Centre: National Centre for Disaster Mitigation and Management
Course Code: EQT	**Course Name:** Stability Analysis of Structures
Credit: 3	**L-T-P:** 3-0-0
Version: 2021	**Approved on:**
Pre-requisite course:	

COURSE CONTENT:

Beam – column – Differential equation. Beam column subjected to (i) lateral concentrated load, (ii) several concentrated loads, (iii) continuous lateral load. Application of trigonometric series, Euler's formulation using fourth order differential equation for pined – pined, fixed – fixed, fixed – free and fixed – pinned column.

Buckling of frames and continuous beams. Elastic Energy method: Approximate calculation of critical loads for a cantilever. Exact critical load for hinged – hinged column using energy approach. Buckling of bar on elastic foundation. Buckling of cantilever column under distributed loads. Determination of critical loads by successive approximation. Bars with varying cross section. Effect of shear force on critical load. Column subjected to non – conservative follower and pulsating forces.

Buckling of frames and continuous beams. Elastic Energy method: Approximate calculation of critical loads for a cantilever. Exact critical load for hinged – hinged column using energy approach. Buckling of bar on elastic foundation. Buckling of cantilever column under distributed loads. Determination of critical loads by successive approximation. Bars with varying cross section. Effect of shear force on critical load. Column subjected to non – conservative follower and pulsating forces.

Stability analysis by finite element approach – deviation of shape function for a two nodded Bernoulli – Euler beam element (lateral and translation of) – element stiffness and element geometric stiffness matrices – assembled stiffness and geometric stiffness matrices for a discretised column with different boundary condition – calculation of critical loads for a discretised (two elements) column. Buckling of pin jointed frames (maximum of two active DOF) – symmetrical single bay portal frame.

Lateral buckling of beams – differential equation – pure bending – cantilever beam with tip load – simply supported beam of I section subjected to central concentrated load. Pure Torsion of thin – walled bars of open cross section. Non – uniform Torsion of thin – walled bars of open cross section.

Expression for strain energy in plate bending with in plate forces (linear and non – linear). Buckling of simply supported rectangular plate – uniaxial load and biaxial load. Buckling of uniformly compressed rectangular plate simply supported along two opposite sides perpendicular to the direction of compression and having various edge condition along the other two sides

Reference Books/Resource Material

1. Stephen P.Timoshenko, James M Gere, "Theory of Elastic Stability"-2nd Edition, McGraw – Hill, New Delhi.
2. Robert D Cook et.al, "Concepts and Applications of Finite Element Analysis"-3rd Edition, John Wiley and Sons, New York.
3. S.Rajashekar, "Computations and Structural Mechanics"-Prentice – Hall, India.

UG/PG: PG	**Department/Centre:** National Centre for Disaster Mitigation and Management
Course Code: EQT	**Course Name:** Theory of Elasticity
Credit: 3	**L-T-P:** 3-0-0
Version: 2021	**Approved on:**
Pre-requisite course:	

COURSE CONTENT:

Analysis of Stress: Definition and notation of stress, equations of equilibrium in differential form, stress components on an arbitrary plane, equality of cross shear, stress invariants, principal stresses, octahedral stress, planes of maximum shear, stress transformation, plane state of stress, Numerical problems

Analysis of Strain: Displacement field, strains in term of displacement field, infinitesimal strain at a point, engineering shear strains, strain invariants, principal strains, octahedral strains, plane state of strain, compatibility equations, strain transformation, Numerical Problems.

Two-Dimensional classical elasticity Problems: Cartesian co-ordinates - Relation between plane stress and plane strain, stress functions for plane stress and plane strain state, Airy's stress functions, Investigation of Airy's stress function for simple beams, bending of a narrow cantilever beam of rectangular cross section under edge load. Bending of simply supported beam under UDL. General equations in polar coordinates, stress distribution symmetrical about an axis, Thick wall cylinder subjected to internal and external pressures, Numerical Problems.

Axisymmetric and Torsion problems: Stresses in rotating discs of uniform thickness and cylinders. Torsion of circular, elliptical and triangular bars, Prandtl's membrane analogy, torsion of thin walled thin tubes, torsion of thin walled multiple cell closed sections. Numerical Problems

Thermal stress and Elastic stability: Thermo elastic stress strain relations, equations of equilibrium, thermal stresses in thin circular discs and in long circular cylinders. Euler's column buckling load: clamped-free, clamped-hinged, clamped-clamped and pin-ended, Numerical Problems

Books: 1) Theory of Elasticity by Stephen Timoshenko

2) An Introduction to the Theory of Elasticity by R. J. Atkin, N. Fox