DEPARTMENT OF APPLIED GEOPHYSICS
INDIAN INSTITUTE OF TECHNOLOGY (INDIAN SCHOOL OF MINES), DHANBAD

M. Tech. Course (2yrs/Four Semesters)

in

EARTHQUAKE DISASTER, HAZARD AND RISK MITIGATION

SEMESTER-I

Theory						
Sl. No.	**Subject Code**	**Name of the course**	**L**	**T**	**P**	**Credits Points**
1.	**GPC51101** **GLC51102**	Applied Seismology/ Soil Engineering	3	0	0	6
3.	**GPC51102**	Near Surface Geophysics and Geotechnical Modeling	3	1	0	7
3.	**GPC51103**	Seismic Hazard Zonation	3	1	0	7
4.	**GPC51104** **CEC51101**	Earthquake Forecasting and Prediction / Structural Dynamics	3	1	0	7
5. Elective (Any one)			3	0	0	6
a.	**GPE51105**	Natural Disasters, Mitigation and Management				
b.	**GPE51106**	Disaster Induced Risk Analysis				
c.	**GPE51107**	Geohydrology				
Practical						
1.	**GPC51201** **GLC51202**	Applied Seismology/ Soil Engineering	0	0	3	3
2.	**GPC52202**	Near Surface Geophysics and Geotechnical Modeling	0	0	3	3
3.	**GPC51203** **CEC51201**	Earthquake Forecasting and Prediction/ Structural Engineering Laboratory	0	0	3	3
		Total:	**15**	**2**	**9**	**41**

SEMESTER-II

Theory						
Sl. No.	**Subject Code**	**Name of the course**	**L**	**T**	**P**	**Credits Points**
1.	**GPC52111**	Computational Seismology	3	0	0	6
2.	**GPC52112**	Earthquake Hazard, Exposure, Vulnerability and Risk	3	1	0	7
3.	**GPC52113/** **CEC52102**	Advanced Remote Sensing and Geographical Information System/Seismic Analysis and Design of Structures	3	1	0	7
4.	**HSC52154**	Entrepreneurship, Incubation and Innovation Policies	3	0	0	6

5. Elective (Any one)			3 0 0	6
a.	**GPE52115**	Near Surface Drilling		
b.	**GPE52116**	Earthquake Building Codes and Safety Seismic Design		
c.	**GPE52117**	Finite Element Analysis in Structural and Geotechnical Modelling		
Practical				
1.	**GPC52211**	Computational Seismology	0 0 3	3
2.	**GPC52212**	Earthquake Hazard, Exposure, Vulnerability and Risk	0 0 3	3
		Total:	**15 2 6**	**38**

SEMESTER-III

Sl. No.	**Subject Code**	**Name of the course**	**L T P**	**Credit Points**
1.	**GPC53621**	Industrial training / Minor Project	0 0 0	4
2.	**GPC53022**	Seminar and Viva-Voce on Industrial Training / Minor Project	0 0 0	2
3.	**GPC53523**	Comprehensive Viva-Voce	0 0 0	4
4.	**GPC53824**	Dissertation (Interim) Fieldwork/Lab work	0 0 0	15
5.	**GPC53825**	Seminar and Viva-voce on Interim Dissertation	0 0 0	10
6.	**GPC53026**	Teaching Assignment Evaluation/Laboratory Development Work etc.	0 0 0	5
		Total:	**0 0 0**	**40**

SEMESTER-IV

Sl. No.	**Subject Code**	**Name of the course**	**L T P**	**Credit Points**
1.	**GLC54831**	Dissertation	0 0 0	20
2.	**GLC54432**	Seminar on Dissertation	0 0 0	5
3.	**GLC54533**	Viva-Voce on dissertation	0 0 0	10
4.	**GLC54034**	Teaching Assignment Evaluation/ Laboratory Development Work etc.	0 0 0	5
		Total:	**0 0 0**	**40**

SEMESTER-I

GPC51101 Applied Seismology 3 0 0

Phenomena of earthquake and its effects, causes of earthquakes. Foreshocks, Mainshocks, Aftershocks studies. Elastic rebound theory, intra and inter plate earthquakes, classification of earthquakes, Temporal and geographical distribution of earthquakes, Seismicity and Seismotectonics of India and Himalaya, Frequency - Magnitude relation. Micro-earthquakes, induced seismicity.

Intensity scales. Magnitude scales. Localizing of magnitude scale, various magnitude scales and their limitations, seismic moment, stress drop and dimension of rupture during earthquakes.

Theory of elasticity, generalized Hooke's law, different types of elastic waves and their propagation characteristics, Momentum equation, Derivation of P- and S-waves equation, Attenuation and dispersion of seismic waves. Ray characteristics and related parameters for horizontally and spherically stratified earth.

Fault plane solutions and related interpretation, moment tensors for different fault patterns, earthquake characteristics along constructive, conservative and destructive boundaries.

Introduction to earthquake prediction

Strong Ground Motions: Ground motion, Site effects, Sensor response; Response spectrum: Construction, Characteristics, and Design of response spectrum

Seismological instrumentation: Short-period, long-period and broadband seismometers.

Textbooks/References

1. Shearer, P. 1999. Introduction to Seismology, Cambridge: Cambridge University Press
2. Stein, S. and Wysession, M. 2003. An Introduction to Seismology, Earthquakes and Earth Structure, Oxford: Blackwell Publishing.
3. Båth, M., 1976. Introduction to Seismology, Birkhäuser Basel
4. Lowrie, W., 2007. Fundamental of Geophysics, Cambridge: Cambridge University Press
5. Agustin, U., 2000. Principles of Seismology, Cambridge: Cambridge University Press
6. KIyoo Mogi, 1985. Earthquake Prediction, Academic Press
7. Kasara, K., 1981. Earthquake mechanics, Cambridge University Press
8. Bullen, K. E. and Bolt, B. A. 1985. An Introduction to the Theory of Seismology, Cambridge: Cambridge University Press
9. Richter, C. F. 1945. Elementary Seismology, W H Freeman, San Francisco, W. H. Freeman & Co.
10. Kulhanek, O. 1970. Anatomy of Seismograms, Seismological section, University of Uppsala, Uppsala, Sweden

GPC51201 Practical (Applied Seismology) 0 0 3

1. Understanding the instruments and other facilities available in the geodetic observatory.
2. Visit to the broadband seismic observatory and analysis of real-time earthquake recording.
3. Analysis the seismogram of local, regional and teleseismic earthquake events.
4. Identification of all the seismic phases on the broadband record of local, regional and teleseismic earthquake events.

5. Coda magnitude estimation of local earthquake event. Computation of tentative location of earthquake using 3-components broadband digital record, and plotting on a map
6. Computation of origin time of local earthquake using Wadati diagram.
7. Reconstruction of intensity map on the basis of a field survey.
8. Richter magnitude calculation using attenuation data of a local earthquake. Comparison of estimated magnitudes of same earthquake using different seismographs.
9. Interpretation of focal mechanism solutions.

GLC51102 Soil Engineering 3 0 0

Factors influencing nature and formation of soils. Soil structure, types of bonds. Important clay materials. Engineering properties of soils, Genetic and engineering classification of soils, Complexity of soil nature. Permeability and flow through soil media, Soil stress and seepage, compressibility and consolidation. Shear strength of cohesion-less and cohesive soils. Soil stress, effective stress, pore water pressure parameters. Earth pressures, active and passive. Stability analysis of soil slopes. Type of foundations, settlement of foundations, bearing capacity, pile foundations. Type of soils as an aggregate material.

Textbooks/References

1. Harr, M.E, Foundations of Theoretical Soil Mechanics, McGraw-Hill Inc., 1996.
2. Das, B.M, Advanced Soil Mechanics, McGraw-Hill Book Co., 1987.
3. Poulos, H.G. and Davis, E.H, Elastic Solutions for Soil and Rock Mechanics, Wiley, 1974.

GLC51202 Practical (Soil Engineering) 0 0 3

1. Determination of physical and engineering properties of soils.
2. Atterberg limits, consistency limits.
3. Direct shear strength triaxial shear (Drained and undrained tests).
4. Permeability by falling head and constant head method.

GPC51102 Near Surface Geophysics and Geotechnical Modelling 3 1 0

Definition of Near Surface Geophysics, its Branches and Users. Types of Seismic waves, Geophones, Seismic energy sources used for near surface investigation. Reflection and refraction at horizontal interface, velocity and depth determination. Fundamentals of up-hole seismic tomography, Cross-hole seismic tomography, Up-hole Shear-wave velocity tomography and their application for near surface investigation. Studies of MASW and ReMi for near surface characterization, Seismic Refraction Tomography study for Geotechnical modelling.

True and apparent resistivity, resistivities of common rocks and minerals. Electrode configurations—Schlumberger and Wenner, Vertical Electrical Sounding, Interpretation of two layered VES curves. Electrical resistivity Tomography (ERT) for near surface characterization, GPR study for near surface modelling

Concept of geotechnical modelling/characterization. Geotechnical investigations for dams, reservoirs, tunnels and mass movements. Slope stability Monitoring and remedies. Geotechnical instrumentation for geotechnical Monitoring

Liquefaction and lateral spreading - Liquefaction related phenomena, Liquefaction susceptibility. Evaluation of liquefaction by cyclic stress and cyclic strain approaches, Lateral deformation and spreading, Criteria for mapping liquefaction hazard zones.

Seismic Cone Penetrometer Test, Cone Penetration Test, Standard Penetration Test, Cyclic Stress Ratio, Cyclic Resistance Ratio, estimation of blow count 'N' of SPT from Shear Wave.

Textbooks/References

1. William Lowrie, 2007, Fundamental of Geophysics. Cambridge University Press pp 381.
2. Telford, W. M., Geldart, L. P., Sheriff, R. E. and Keys, D. A., 1990, Applied Geophysics. Cambridge University Press, pp770.
3. Kramer, S. L., "Geotechnical Earthquake Engineering", Pearson Education.
4. Ansal, A., "Recent Advances in Earthquake Geotechnical Engineering and Microzonation", Springer

GPC-52202 Practical (Near Surface Geophysics and Geotechnical Modelling) 0 0 3

1. Field demonstration for seismic data acquisition
2. Interpretation of seismic refraction data
3. Field demonstration for different resistivity data acquisition
4. Interpretation of different Resistivity data
5. Interpretation of ERT and SRT section and site characterization
6. Estimation of different engineering properties
7. Interpretation of MASW section and Site classification based on Vs30

GPC52202 Practical (Near Surface Geophysics and Geotechnical Modelling) 0 0 3

8. Field demonstration for seismic data acquisition
9. Interpretation of seismic refraction data
10. Field demonstration for different resistivity data acquisition
11. Interpretation of different Resistivity data
12. Interpretation of ERT and SRT section and site characterization
13. Estimation of different engineering properties
14. Interpretation of MASW section and Site classification based on Vs30

GPC51103 Seismic Hazard Zonation 3 0 0

Introduction to seismic hazard zones; historical development of seismic macrozonation maps, scales and types of zonation (Microzonation, Macrozonation and Nanozonation); Issues related to seismic zonation, Components of seismic macrozonation and codal Provisions in India; Global seismic hazard assessment programme (GSHAP).

Definition, steps and site characterization in seismic microzonation. Generalized methodology for microzonation; issues related to microzonation, some example of microzonation in India; data requirement: geological, geophysical and geotechnical; probabilistic and deterministic hazard assessment; ground shaking, site response, liquefaction studies

Site response characteristics: H/V method and SASW method; fundamental frequency and site amplification: relation surface geology; factors affecting site response; determination of shear wave velocity and attenuation factor (Q).

Outputs of seismic microzonation: fundamental frequency map, amplification map, probability of exceedance of strong ground motion; peak ground acceleration map at different return periods and Liquefaction potential maps; limitation of seismic microzonation

Textbooks/References

1. Kramer, S. L., "Geotechnical Earthquake Engineering", Pearson Education.
2. Nath, S.K., "Seismic Microzonation Handbook", MoES, Govt. of India
3. Reiter, L., "Earthquake Hazard Analysis, Issues and Insights", Columbia University Press "Seismic Microzonation: Methodology for Vulnerable cities of South Asian Countries" SAARC Disaster Management Center, New Delhi, India
4. Ansal, A., "Recent Advances in Earthquake Geotechnical Engineering and Microzonation", Springer
5. "Geotechnical/Geophysical Investigations for Seismic Microzonation Studies of Urban Centres in India- Technical Report", NDMA, New Delhi

GPC51104 Earthquake Forecasting and Prediction 3 1 0

Definition of Earthquake Forecasting and prediction: Definition and Validity

Types of earthquake forecasting (long term, middle-term and short-term); Historical perspective of earthquake prediction; Case studies on earthquake prediction: success and failure.

Long-term forecasting methods: paleoseismology, historical seismicity trend, recurrence interval, Seismic Gap Hypothesis, movements of known faults,

Statistical models for earthquake prediction: time predictable model, slip predictable model, regional time and magnitude predictable model.

Earthquake precursors: Definition of precursor; Dilatancy model. Scope and relation to earthquake prediction.

Types of precursors: Fault creep, seismic activity and migration, crustal deformation, electrical parameter, magnetic and gravity parameters; radon concentration, ground water changes, precursory swarms, seismic quiescence, thermal anomaly, b-value variations, fractal dimension variations of seismicity; Animal behaviour; Changes in Vp/Vs

GPS study for Total Electron Count (TEC) in ionosphere study and other satellite observations interpretations like thermal, cloud formations etc prior to earthquakes.

Textbooks/References

1. Abbott, Patrick L., 1996, Natural Disasters. Wm. C. Brown Publishing Co., 438 pp.
2. Ragnar Stefánsson, 2011 Advances in Earthquake Prediction: Research and Risk Mitigation, Springer
3. Susan Hough, 2009: Predicting the Unpredictable: The Tumultuous Science of Earthquake Prediction; ISBN: 9780691138169 Edited by: David W. Simpson, Paul G. Richards; 1981: Earthquake Prediction: An International Review, American Geophysical Union, Volume 4
4. K. Moggi; 1985: Earthquake Prediction, Academic Press, 355 pp.

CEC51101 Structural Dynamics 3 1 0

Single Degree of Freedom Systems: Equation of motion, problem statement and solution method, Free vibration, response to harmonic and periodic excitation with damped system. Response to periodic excitation, Response to arbitrary, step and pulse excitation. Numerical evaluation of dynamic response. Generalised single degree of freedom systems, Dynamic analysis and response of two degree of freedom systems, modal analysis. Multi-Degree of freedom system: Eigen value problem, modal analysis, Rayleigh's quotient. Continuous systems: Exact solution, approximate solution.

Textbooks/References

1. Dynamics of Structures: Applications to Earthquake Engineering" by A. K. Chopra, **5th Edition,** Prentice-Hall International Series.
2. Elements of Vibration Analysis" by L. Meirovitch
3. Structural Dynamics : Theory and Computation" by Mario Paz
4. Datta, T. K. (2010). "Seismic analysis of structures", John Wiley & Sons (Asia) Pte Ltd. Singapore.
5. Agrawal, P. and Shrikhande, M. (2006), "Earthquake resistant design of structures", Prentice Hall of India, Inc.
6. Chowdhary, I. and Dasgupta, S.P. (2009). "Dynamics of structure and foundation – A unified approach : 2 Applications", CRC Press, Balkema.
7. Clough, R. W. and Penzien, J. (1993). "Dynamics of structures", McGraw Hill, Inc., New York.

CEC51201 Practical (Structural Engineering Laboratory) 0 0 3

Properties of fresh and hardened concrete, concrete mix design, Tests on RC beam, under-reinforced and over reinforced beams. Buckling of Steel column; NDT of RC structures. Durability of Concrete: Shrinkage, RCPT, Water absorption, Corrosion test of concrete. Stress analysis: two and three- dimensional photo elasticity, study of dynamic properties of structures using shake table

GPE51105 Natural Disasters, Mitigation and Management 3 0 0

Define disaster. Define types of disasters. Examples of natural and man-made disasters. Earthquake, Tsunami, Volcanic eruption, Snow storm / avalanche, Glacial lake outburst, Lightning, Windstorm, Thunderstorm, Hailstorm Tornado, Cyclone/ Hurricane, Asteroid impacts

Flood, Dust storm, Drought, Landslides, Subsidence, Erosion, Desertification, Coal fires, Greenhouse effect, Crop disease, Coral reef decline, Acid rain, Ozone depletion, Oil spill, Water / soil / air pollution.

Mitigation and Management:

Pre-Disaster: Prediction, Social Aspects, Preparedness

Post-Disaster: Relief Operations, Emergency Management, Recovery Plans, Rehabilitation.

Textbooks/References

1. Reiter L., Earthquake Hazard Analysis: Issues and Insights, Columbia University Press.
2. Donald Hyndman and David Hyndman, Natural Hazards and Disasters, Publisher: Cengage Learning, 2013, 576 pages.
3. Edward A. Keller and Duane E. DeVecchio, Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes (3rd Edition), Publisher: Prentice Hall, 2011, 528 pages.
4. Bryant E., Natural Hazards, Cambridge University Press
5. Patrick Alvintzi and Hannes Eder, Crisis Management, 2011, Publisher: Nova Publisher

GPE51106 Disaster Induced Risks Analysis 3 0 0

Introduction and scope: Natural and anthropogenic disasters. Hazards and disasters: emergencies, disasters and related concepts, nature-society interface, fragmented Vs systems thinking, concept of disaster systematics, simple and compound disasters. Disasters Vs development: Disaster-development linkages, interaction of socio-economic developmental activities and disasters, development plans incorporating disaster risks; Human Development Index (HDI) Vs Disaster Risk Index (DRI), cross-cutting themes in Disaster-Development interface. Causes and effects of disasters: Hazards, vulnerability and risk; Risks taxonomy according to hazardous agents such as physical, chemical, and biological agents, natural forces, social-communicative hazards, and synergic (or complex) manmade-systems hazards; Risk patterns at the national and local levels; Disasters and climate change. Risk governance framework: Risk perception, pre-assessment, appraisal, characterization and evaluation, analysis, assessment, communication, management and governance. Risk assessment: Hazard identification and estimation, exposure / vulnerability assessment, risk estimation; Risk characterization: Simple risk problems, complexity-induced risk problems, uncertainty-induced risk problems, ambiguity-induced risk problems. Impacts of disasters: Impacts on the environment, critical infrastructure and socio-economic systems, factors affecting social vulnerability to hazards, short-term and long-term impacts, systemic resilience, emergency response; Disaster recovery and rehabilitation; Lessons learnt for better policies and programs to effectively mitigate and manage future disasters. Present status and future directions in assessment and management of disaster-induced risks and impacts: Hazard specific risk profiles, risks in urban and rural settings, disaster indicators, disaster risk and impacts in the context of global change and technological advancement, multi-hazard disaster risk and impact modeling; Integrated climate risk management.

Textbooks / References

1. Grossi, P. and Kunreuther, H. (eds.), Catastrophe Modeling: A New Approach to Managing Risk, Springer – 2005.
2. Kirschenbaum, Chaos Organization and Disaster Management, Alan Marcel Dekker 2004.
3. MacDaniels T.L. and Small M.J. (eds.) Risk Analysis and Society: An Interdisciplinary Characterization of the Field, Cambridge University Press-2004.
4. Jaeger,C., Renn,O., Rosa, E. and Webler, T., Risk, Uncertainty and Rational Action, Earthscan -2001.WBGU (Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen), World in Transition: Strategies for Managing Global Environmental Risks, Springer 2000.

GPE51107 Geohydrology 3 0 0

Hydrologic Cycle, Types of hydrometeorological data and their importance, time oriented, space oriented and relational data. Observation of hydrometeorological data - rainfall, temperature, evaporation, discharge and other parameters, observational and instrumental errors and quality control. Guidelines of WMO, BIS & ISO. Storage, transmission and retrieval of data, different formats adopted by IMD, CWC and WMO. Design and optimization of monitoring systems for rainfall, evaporation, gauge and discharge networks and groundwater data monitoring stations. Estimation of missing data in rainfall, runoff and other parameters, record extension for rainfall and runoff data, interpolation and kriging techniques, statistical rainfall-runoff models. Development of stage discharge curves using graphical, physical and analytical methods for various types of streams. Automatic weather stations - types, data storage and retrieval; Automatic water level recorders - types, data storage and retrieval. Analysis of randomness and trends in hydrometeorological data; Computation of statistical parameters and standards errors, components of time series, concepts of short and long term dependence in hydrometeorological data. Estimation of extremes using frequency analysis; Graphical and analytical methods for normal, lognormal and Gumbel distributions. Case Studies.

Textbooks / References

1. Kottegoda N.T., “Stochastic Water Resources Technology”, John Wiley & Sons – 1980.
2. Chow V. T., Maidment D. R. and Mays L. W., “Applied Hydrology”, McGraw-Hill-1988.
3. Maidment, D.R., “Handbook of Hydrology”, McGraw Hill Inc. -1993.
4. Singh V. P., “Elementary Hydrology”, Prentice-Hall of India Private -1994.
5. Hornberger G. M., Raffensperger J. P., Woberg P. L and Eshleman K. N., “Elements of Physical Hydrology”, The Johns Hopkins University Press - 1998.
6. S.K. Jain & V.P. Singh, “Water Resources Systems Planning and Management”, Elsevier ISBN: 8131205916 (HB)-2006.
7. Viessman W. and Lewis G. L., “Introduction to Hydrology”, Pearson Education - 2007.
8. Subramanya K., “Engineering Hydrology”, Tata McGraw Hill Ltd.- 2008.

SEMESTER-II

GPC-52111 Computational Seismology 3 0 0

Equations of continuity and motion, Work and Energy, Potential functions of displacements and forces, Green function of elastodynamics, Theorems of reciprocity and representation.

Equation of motion of Raleigh and Love waves, The effect of gravity on seismic wave propagation, Determination of phase and group velocity for surface wave, Geometry of P and S wave displacements, anisotropy, Travel time tomography.

Equivalent forces: Point sources, Force couples: Single and double couples, Fractures ad dislocations, Circular and rectangular fracture modeling, Nucleation, propagation and arrest of rupture, near field and far field spectra. First motion focal mechanisms, body wave ad surface wave focal mechanisms, Moment tensor and inversion, Types of sources and separation of the moment tensor, Source time function, Waveform modeling,

Textbooks/References

1. Shearer, P. 1999. Introduction to Seismology, Cambridge: Cambridge University Press
2. Stein, S. and Wysession, M. 2003. An Introduction to Seismology, Earthquakes and Earth Structure, Oxford: Blackwell Publishing.
3. Lowrie, W., 2007. Fundamental of Geophysics, Cambridge: Cambridge University Press
4. Bullen, K. E. and Bolt, B. A. 1985. An Introduction to the Theory of Seismology, Cambridge: Cambridge University Press
5. Gubins D., 1990. Seismology and Plate Tectonics, Cambridge University Press, pp. 348.
6. Aki, K. and Richards, P.G., 2009. Quantitative Seismology, Second edition, University Science Books, U.S., pp. 700

GPC51201 Practical (Applied Seismology) 0 0 3

1. Acquaintance of Seisan Software.
2. Computation of corner frequency, stress drop, moment magnitude, source radius, etc. of local earthquake source using Seisan Software.
3. Computation of seismic wave attenuation using Seisan Software.
4. Coda magnitude estimation of local earthquake event. Computation of tentative location of earthquake using 3-components broadband digital record, and plotting on a map
5. Computation of travel time curve for a deep focus earthquake.
6. Reconstruction of ground motion acceleration map using intensity map.
7. Computation of angle of incidence of P-wave for shallow focus earthquake.
8. Computation of fault plane solutions using first P-wave motion.
9. Computation of fault plane solutions using Seisan Software.
10. Computation of dispersion curve using surface wave.

GPC52112 Earthquake Hazard, Exposure, Vulnerability and Risk 3 1 0

Definition of Seismic hazard; Seismicity data analysis: compilation of seismic catalogue, removing duplicate events, foreshocks and aftershocks, homogenization of magnitude scale, completeness analysis with respect to magnitude and time; earthquake occurrence models: frequency-magnitude recurrence model, Poissonian model, non-Poissonian models (Lognormal, Weibull, Gamma distributions, extreme value statistics – Gumbel I, II and III type distributions);

Probabilistic and deterministic approaches, uncertainties in seismic hazard assessment; earthquake sources (point, line, and areal); estimation of maximum magnitude: maximum credible earthquake (MCE), design basis earthquake (DBE), maximum probable earthquake (MPE); ground motion attenuation relations, disaggregation, Peak ground acceleration (PGA) at bed rock level and surface; PGA values at different return periods; probability of exceedance of strong ground motion

Definition of Exposure, Vulnerability and Risk; Grades of damages, direct and indirect damages, damage to structures, structure types, quantitative analysis, lessons learnt from past earthquakes; Seismic vulnerability assessment – various methodologies; Building stock inventory, sources of available information, census data; intensity scales; use of intensity scales for estimating seismic vulnerability;

Convolution of hazard; vulnerability and exposure to quantify risk; loss ratios

Textbooks/References

1. Kramer, S. L., "Geotechnical Earthquake Engineering", Pearson Education.
2. McGuire, Robin K., "Seismic Hazard and Risk Analysis", Earthquake Engineering Research Institute
3. Stein, S. and Wysession, M., "An Introduction to Seismology, Earthquake and Earth Structures", Black Well Publications
4. Reiter, L. "Earthquake Hazard Analysis, Issues and Insights", Columbia University Press
5. Coburn, A. and Spence R., "Earthquake Protection", John Wiley and Sons, Ltd

GPC52113 Advanced Remote Sensing and Geographical Information System 3 1 0

Definition and overview of remote sensing, electromagnetic radiation laws. Interaction of EMR with atmosphere and surface of the earth. Atmospheric window, spectral signature, spectral reflectance, spectral response of vegetation, water, soil, etc. Principle and operations of different sensor array, Detectors-sensors. Geometry of satellite Remote sensing. Different resolution and their application, Applications of different sensor bands.

Digital Image Processing: pre-processing-image correction, radiometric correction, geometric correction, spatial, spectral, radiometric and temporal enhancement, indices and image fusion. Supervised and un supervised classification techniques

Ground truth collection, Visual and digital interpretation techniques for mapping of rock types, faults/folds and joints and other curvilinear and circular features as applicable for mineral and land use land cover, land slide etc.

Geographical Information System (GIS): Definition of GIS, data input and output; Editing, Topology, Interpolation methods, geospatial analysis, Data base query, geospatial measurement, overlay operation, Surface analysis, geovisualization.

Applications of remote sensing and GIS : study for geological mapping, earthquakes, environmental impact assessment studies, land use land cover, change detection, landslides, construction materials, water, watershed management, soil, buildings, railways and highways etc. using remote sensing and GIS.

Textbooks/References

1. B. Bhatta.(2010) Remote Sensing and GIS. Oxford University press
2. George Joseph (2005), Fundamental of Remote Sensing. Universities press
3. Rafael C.G. and Woods R.E.(1992) Digital Image Processing
4. Lillesand T.M.; Kiefer R.W. and Chipman J.W. (2012) Remote Sensing and Image Interpretation, Wiley.
5. Damen M.C.J., Smith G.S. and Kerstappen (Ed) ( ) Remote Sensing for Resources Development and Environmental Management 3rd volume Set Netherlands: Balkema.
6. John R. Jensen Digital Image processing: A Remote Sensing Perspective, Prentice-Hall, 2004
7. Ulaby F.T., Moore R.K. and Fung A.K. (1986) Microwave Remote Sensing: Active and Passive, from Theory Applications. Artech House Publishers, 1986.

CEC 52102 Seismic Analysis and Design of Structures 3 1 0

Concepts of Earthquake Resistant Design: Force based vs. displacement based design, performance based design, seismic input characteristics and their effect on seismic design, comparative study of different national codes.

Strength and ductility of RC, steel and masonry structures, nonlinear static and dynamic analyses.

Direct Displacement Based Design: Structure performance objectives, performance levels and limit states; P-Delta effects; Torsion; Capacity design for direct displacement based design.

Textbooks/References

1. Agrawal, P. and Shrikhande, M. (2006), "Earthquake resistant design of structures", Prentice Hall of India, Inc.
2. Chopra, A.K. (2007), "Dynamics of structures: Theory and application to earthquake engineering", 2nd edition, Prentice Hall of India.
3. Clough, R. W. and Penzien, J. (1993). "Dynamics of structures", McGraw Hill, Inc., New York.
4. Datta, T. K. (2010). "Seismic analysis of structures", John Wiley & Sons (Asia) Pte Ltd. Singapore.

HSC52154 Entrepreneurship, Incubation and Innovation Policies 3 0 0

Introduction to Academia-Industry and Government Interaction: The Role and the Creation of Intellectual Capital, Emergence of Entrepreneurial University, From Knowledge Production to Knowledge Commercialization.

Introduction to Entrepreneurship and Incubation: A Social Science View, Technology and Business Incubator, A Road Map to Develop an Enterprise, the Role of Entrepreneurship and Incubation Centres, Technology, Employment and Economic Development.

Interface of Two Culture of Science: Basic Research and Industrial R&D-Two Perception of Science Development, The relations between R&D, Patenting and Innovative Activities, Technology Transfer (Emulation) versus Technological Innovation (Creativity).

Innovation as Social Process and Creative Destruction- Innovation as Creative Destruction, Entrepreneurship and Incubation: Innovation as Social Process, The Rise of Multinational Firms, The Social Networks in the Process of Incubation and Entrepreneurship.

Understanding the Incubation Project Development Process: Introduction to New Business Startups, Three Phases of Incubation Development: 1) Pre Inception Stage, 2) Idea Development and Maturity, 3) Establishing Business Enterprise.

How to Identify the Socio-technological Issues: Socio-Anthropological Understanding, Scientists/Engineers as Sociologist and Economist.

Role of Patent and Knowledge Transfer Agencies: Introduction to Technology Development Agencies in India, Identifying and Knowing the Role of Technology Transfer Office.

The Global Innovation Policies: Innovation Policies in First World Countries: USA, Europe and Japan: Innovation Policies From BIRC Nations in Brazil, India, Russia and China.

Textbooks/References

1. Bijker, W. E. (1995). Of Bicycles, Bakelites, Bulbs. London, England: The MIT Press.
2. Carlson, B, W. (1991). Innovation as a Social Process: Elihu Thomson and the Rise of General Electric, 1870-1900. Cambridge University Press: Cambridge.
3. Flichy, P. (2007). Understanding Technological Innovation. Cheltenham, UK Northampton, MA, USA: Edward Elgar Publishing Limited.
4. Hughes, T. P. (1999b). The Evolution of Large Technological Systems . In M. Biagioli, The Science Studies Reader (pp. 202-224). New York: Routledge.

GPE52115 Near Surface Drilling 3 0 0

An overview of Drilling Technology; definition, purposes and different terminology used in Drilling, operations associated with the drilling process; Classification of drilling methods (Conventional and non-conventional drilling methods); Principle of rock tool interaction in drilling: Percussion Drilling and Rotary drilling; International Association for Drilling Contractors (IADC) codes for Rotary drilling; Assemblies in Rotary Blast Hole Drill; Hole Cleaning and Bailing Velocities; Fishing and Fishing tools; Fishing operation; Factors Affecting Drilling; Drilling Performance Measurement; Criteria for Selection of Drilling Method and Drilling Execution; Small diameter blast-hole drill; Application of different drilling methods; Selection of drills; Method of measuring drilling performances;

Drilling Fluids; Mud properties; Mud Maintenance; Mud additives and causes of their need while drilling; Post Drilling activity (Deviation Test and Logging, Recovery of Casings, Restoration of Drill Site, Soil Sampling through Core Drilling & S.P.T.

Measure while log and while drilling; Current safety practices; Drilling trends and new technology; Basic communications and supervisory skills to ensure a safe, efficient operation; Management of Drilling Operation: Permissible noise exposure, Drilling Proper, Drill Relocations, Operation and Maintenance, Competency Assessment; Safety at Drilling Operations; Monitoring of drilling conditions; Problems of Drilling; Drilling Hazard

Textbooks/References

1. Geotechnical Earthquake Engineering by Steven Kramer, ISBN 0-13-374943-6
2. Blasthole Drilling Technology; Gokhale, B. V. 2003, Publisher: Multifields, Mumbai
3. Rotary Drilling and Blasting in Large Surface Mines; Bhalchandra V. Gokhale; CRC Press, 2011
4. Drilling and Blasting, Part 1, Antipas Massawe; LAP Lambert Academic Publishing, 2010

GPE52116 Earthquake Building Codes and Safety Seismic Design 3 0 0

Earthquake engineering: an overview; development of seismic zoning map of India. Bureau of Indian Standards Act 1986; History of development of Indian standards (IS); Indian standards (IS) on Earthquake engineering; different earthquake building design codes in Indian Standards; International aspect on seismic design codes, comparative study of different national codes; implementation of building codes in India

Concepts of Earthquake Resistant Design: Force based vs. displacement based design; performance based design, seismic input characteristics and their effect on seismic design, Sources of earthquake ground motions; measures of earthquake intensity and damage potential; effects of local soil conditions on ground shaking; engineering estimation of ground motion characteristics based on deterministic and probabilistic approaches

Engineering Characterization of Ground Motions; Sensitivity of Seismic Response of Simple Systems to Ground Motion and Structural Characteristics; Development of Design Earthquakes (Linear & Nonlinear); Analytical Tools for Preliminary/Conceptual Design; Design Issues and Approaches (Code-related Issues - Interpretation and future trends; Performance-based Design; Capacity Design/Damage Tolerant Design); Applications: Moment Resisting and Braced Frames (mainly steel); New construction and retrofit

Textbooks/References

1. IS 4326:1993 Code of practice for earthquake resistant design and construction of building, Bureau of Indian Standards
2. IS 456:2000 code of practice for plain & reinforced Concrete?
3. IITK-BMTPC earthquake Tips, Building materials & technology promotion council, New Delhi.
4. Proceeding of training course on earthquake resistant design and construction of buildings-IIT Roorkee and BMTPC 2006.

5. IS 13920:1993 code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces, Bureau of Indian Standards?
6. National Building code 2003, Bureau of Indian Standards.
7. The Seismic Design Handbook, F. Naeim, Ed., Van Nostrand/Reinhold, New York, NY, 1989.
8. Earthquake Resistant Design, Dorwick, D., Wiley, New York, NY, 1989.

GPE52117 Finite Element Analysis in Structural and Geotechnical Modelling 3 0 0

Introduction to FEM for Deformation Analysis, Discretization of a Continuum, Element shapes, nodes, nodal unknowns and coordinate systems, discretisation, meshing, finite element method Vs Classical method, Basic equation of elasticity: equation of equilibrium, strain displacement equation

Shape functions: polynomial shape function, convergence requirement, derivation of shape function, Lagrange polynomials, Serendipity element, Hermite polynomials. Strain displacement matrix: bar element, CST element, beam element.

Assembling stiffness equation by Galerkin's method, Virtual work method. Assembling stiffness equation using variational method. Discritization of structures, Formulation of Stiffness Matrix, FEM analysis of plane stress and plane strain problem, Isoparametric formulation.

Constitutive laws for soils, Nova model, Vermeer's model. Matrix displacement formulation: solution of matrix displacement equation, Mohr – Coulomb criterion.

FEM in incompressible and compressible fluid, applications of FEM in thermal problems.

Textbooks/References

1. O.C. Zienkiewicz and R.L. Taylor, Finite element methods Vol I & Vol II, McGraw Hill, 1989, 1992.
2. K.J. Bathe, Finite element procedures, PHI Ltd., 1996.
3. R.D. Cook, D.S. Malkus. and M.E. Plesha, Concepts and applications of finite element analysis, John Wiley and Sons, Third edition, 1989.
4. Sam Helwany, Applied Soil Mechanics with ABAQUS Applications, 2007. ISBN: 978-0-471-79107-2 400 pp, USA.

Semester - I

Theory paper on **"Applied Seismology"** would be offered to students with B.E./B.Tech. Degree in Mining Engineering/ Environmental Science and Engineering/ Civil Engineering background

Theory paper on **"Soil Engineering"** would be offered to rest of the students

Practical paper on **"Applied Seismology"** would be offered to students with B.E./B.Tech. Degree in Mining Engineering/ Environmental Science and Engineering/ Civil Engineering background

Practical paper on **"Soil Engineering"** would be offered to rest of the students

Theory paper on **"Structural Dynamics"** would be offered to students with B.E./B.Tech. Degree in Civil Engineering background

Theory paper on **"Earthquake Forecasting and Prediction"** would be offered to rest of the students

Practical paper on **"Structural Dynamics"** would be offered to students with B.E./B.Tech. Degree in Civil Engineering background

Practical paper on **"Earthquake Forecasting and Prediction"** would be offered to rest of the students

Semester – II

Theory paper on **"Seismic Analysis and Design of Structures"** would be offered to students with Civil Engineering background

Theory paper on **"Advanced Remote Sensing and Geographical Information System"** would be offered to rest of the students