DEPARTMENT OF APPLIED GEOPHYSICS
INDIAN SCHOOL OF MINES, DHANBAD
M Tech course (2yrs/Four Semester) in
EARTHQUAKE DISASTER, HAZARD AND RISK MITIGATION

Course Structure

SEMESTER-I

Theory				
Sl. No.	**Subject Code**	**Name of the course**	**L T P**	**Credits Points**
1.	GPC55105 GLC51102	Introduction to Seismology/Soil Engineering	3 0 0	6
2.	GPC-55101	Strong Motion Seismology and Structural Responses	3 0 0	6
3.	GPC-55102	Near Surface Geophysics and Seismic Microzonation **Section A:** Near Surface Geophysics **Section B:** Seismic Microzonation	 2 0 0 2 0 0	8
4.	GPC-55103	Earthquake Forecasting and Prediction	3 1 0	7
5.	GPC-56103	Natural Disasters, Mitigation and Management	3 0 0	6
Practical				
1.	GPC-55202 GLC51202	Introduction to Seismology/Soil Engineering	0 0 3	3
2.	GPC-55201	Strong Motion Seismology and Structural Responses	0 0 3	3
3.	GPC-55202	Near Surface Geophysics and Seismic Microzonation **Section A:** Near Surface Geophysics **Section B:** Seismic Microzonation	 0 0 3/2 0 0 3/2	3
		Total: 16 1 9		42

SEMESTER-II

Theory				
Sl. No.	**Subject Code**	**Name of the course**	**L T P**	**Credits Points**
1.	GPC-56101	Computational Seismology	3 0 0	6
2.	GPC-56102	Earthquake Building Codes and Safety Seismic Design	3 1 0	7
3.	GPC-55104	Geotechnical Modeling	3 1 0	7
4.	GPC-56104	Near Surface Drilling	3 1 0	7
5.	GPC-56105	Earthquake Hazard, Exposure, Vulnerability and Risk	3 0 0	6

Practical				
1.	GPC-56102	Computational Seismology	0 0 3	3
2.	GPC-56201	Near Surface Drilling	0 0 3	3
3.	GPC-56202	Earthquake Hazard, Exposure, Vulnerability and Risk	0 0 3	3
			Total: 15 3 9	42

		Name of the course		
1.	GPC-57001	Industrial training / Minor Project	0 0 0	4
2.	GPC-57002	Seminar and Viva-Voce on Industrial Training / Minor Project	0 0 0	2
3.	GPC-57501	Comprehensive Viva-Voce	0 0 0	4
4.	GPC-57801	Dissertation (Interim) Fieldwork/Lab work	0 0 0	15
5.	GPC-57802	Seminar and Viva-voce on Interim Dissertation	0 0 0	10
6.	GPC-57003	Teaching Assignment Evaluation/ Laboratory Development Work etc.	0 0 0	5
			Total: 0 0 0	40

SEMESTER-IV

1.	GLC-58801	Dissertation	0 0 0	20
2.	GLC-58802	Seminar on Dissertation	0 0 0	5
3.	GLC-58803	Viva-Voce on dissertation	0 0 0	10
4.	GLC-58804	Teaching Assignment Evaluation/ Laboratory Development Work etc.	0 0 0	5
			Total: 0 0 0	40

Details of Syllabus

SEMESTER-I

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.

GPC55105 Introduction to Seismology 3 0 0

Phenomena of earthquake and its effects. 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 and 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.

Textbooks/References

1. Peter P. M., Shearer, Introduction to Seismology
2. Bath M., Introduction to Seismology
3. Lowrie, W., Fundamentals of Geophysics
4. Agustin U. Principles of Seismology
5. Kiyoo Mogi, Earthquake Prediction
6. Kasara K., Earthquake mechanics

7. Bullen, K. E. and Bolt. B. A., An Introduction to the Theory of Seismology
8. Richter, C. F., Elementary Seismology
9. Kulhanek O, Anatomy of Seismograms

GPC-55101 Strong Motion Seismology and Structural Responses 3 0 0

Ground Motions, Site effects, Sensors; Response spectrum: Construction, Characteristics, Design Response spectrum; Linear Earthquake analysis: Idealization of structures, Response spectrum analysis, Torsionally coupled systems, Frequency domain analysis, Time domain analysis; Nonlinear Earthquake analysis: Force-deformation relationships, Equation of motion, Controlling parameters, Ductility demand, Allowable ductility; Earthquake resistance design: philosophy ductility based design, Detailing provisions, Codal Provisions, Concepts of passive controls; Geotechnical aspects: Dynamic properties of soil, dynamic earth pressures, Liquefaction and ground improvement techniques; Retrofitting and strengthening of Buildings and Bridges.

Ground response analysis – One-dimensional ground response analysis: Linear approaches, Equivalent linear approximation of non-linear approaches, Computer code "SHAKE". Seismic design of foundations, Seismic slope stability analysis: Internal stability and weakening instability and Seismic design of retaining walls.

Textbooks/References

1. R. W. Clough and J. Penzien, Dynamics of Structures, McGraw Hill, Second edition, 1993.
2. M. Paz, Dynamics of Structures, CBS Pub, 1987.
3. A.K. Chopra, Dynamics of Structures-Theory and application to Earthquake Engineering, PHI, 1997.
4. T. Pauley and M.S.N. Priestly, Seismic design of reinforced concrete and masonry buildings, John Wiley and Sons, 1992.
5. M.N.S. Priestly, F. Seible and G.M. Calvi, Seismic design and retrofit of bridges, John Wiley and Sons, 1996.
6. D.J. Dowrick, Earthquake Resistant Design: for engineers and architects, John Wiley and Sons, 1987.
7. Naeim, F., The Seismic Design Handbook, Kluwer Academic Publication, 2nd Edition, 2001.

GPC-55102 Near Surface Geophysics and Seismic Microzonation 4 0 0

Section A: Near Surface Geophysics

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 modeling.

Geotechnical instrumentation, monitoring and modeling.

True and apparent resistivity, resistivities of common rocks and minerals. Fundamental relationship between potential and apparent resistivity. 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 modeling

Section B: Seismic Microzonation

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

GPC-55103 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.

GPC-56103 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 impact, Health disasters, Solar flare, Gamma-ray burst.

Flood, Dust storm, Drought, Landslides, Subsidence, Erosion, Desertification, Coal fires, Coastal erosion, Greenhouse effect, Crop disease, Insect infestation, Forest fire, Mangrove decline, Coral reef decline, Acid rain, Ozone depletion, Armed conflict, Land mines, Nuclear / chemical, accidents, Oil spill, Water / soil / air pollution, Groundwater pollution, Electrical power, mobile phone, breakdown, Pesticides

Mitigation and Management:

Pre-Disaster: Prediction, Social Aspects, Preparedness, Codes and Specifications

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

Applications of Remote sensing and GIS for hazard mapping.

Textbooks/References

1. Kristin O. Reed, Disaster Relief: Organizations, Speed and Efficiency of Response and Roles, Publisher: Nova Publisher, 2011
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. Mark Buchanan, Ubiquity: Why Catastrophes Happen, 2002, Publisher: Three Rivers Press, New York.
5. Patrick Alvintzi and Hannes Eder, Crisis Management, 2011, Publisher: Nova Publisher

SEMESTER-II

GPC-56101 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 af 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. Peter P. M., Shearer, Introduction to Seismology
2. Lowrie, W., Fundamentals of Geophysics
3. Agustin U. Principles of Seismology
4. Scholz, C.H., The mechanics of earthquakes and faulting
5. Gubins D., Seismology and Plate Tectonics

GPC-56102 Earthquake Building Codes and Safety Seismic Design 3 1 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. Earthquake & Engineering Seismology Part A and Part B (International handbook of Earthquake and Engineering Seismology) Edited by William H.K.Lee, Hiroo Kanamori,
2. Paul C. Jenning and Carl Kisslinger, Published by Academic press.ISBN:0-12-440658-0
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 4326:1993 Code of practice for earthquake resistant design and construction of building, Bureau of Indian Standards
6. IS 456:2000 code of practice for plain & reinforced Concrete.
7. IS 13920:1993 code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces, Bureau of Indian Standards.
8. National Building code 2003, Bureau of Indian Standards.
9. Introduction to Structural Dynamics and Earthquake Engineering by Anil Chopra, Prentice Hall, 2000.
10. Earthquake Engineering Handbook, W-F. Chen, C. Scawthorn, CRC Press, 2002.
11. The Seismic Design Handbook, F. Naeim, Ed., Van Nostrand/Reinhold, New York, NY, 1989.
12. Earthquake Engineering, Hu, Y-X, Liu, S-C and Dong, W, E & FN Spon, London, 1996.
13. Earthquake Resistant Design, Dorwick, D., Wiley, New York, NY, 1989.
14. Fundamentals of Earthquake Engineering, Newmark, N. and Rosenblueth, E., Prentice Hall, NY, 1971.

GPC-55104 Geotechnical Modeling 3 1 0

Concept of geotechnical modeling/characterization. Engineering properties of rocks and soils. Various standard codes for geotechnical characterization. Geotechnical investigations for dams, reservoirs, tunnels and mass movements. Slope stability Monitoring and remedies.

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.

Characteristics of different aquifer. Groundwater flow. Groundwater development. Introduction to principles and applications of remote sensing.

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

Seismic design of foundations, Seismic slope stability analysis.

Textbooks/References

1. Kramer S.L., Geotechnical Earthquake Engineering, Prentice Hall, 1996.
2. Day, R.W., Geotechnical Earthquake Engineering Handbook, McGraw-Hill, 2002.
3. Secoe Pinto, P., Seismic behaviour of ground and Geotechnical structure, A. A. Balkema, 1997.
4. Geotechnical Earthquake Engineering, Steven Kramer, Prentice Hall, 1996.
5. Design of Earthquake Resistant Buildings, Wakabayashi, M., McGraw-Hill, New York, NY, 1986.

GPC-56104 Near Surface Drilling 3 1 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

GPC-56105 Earthquake Hazard, Exposure, Vulnerability and Risk 3 0 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, deaggregation, 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