

**INSTITUTE OF GEOLOGY, UNIVERSITY OF THE PUNJAB
LAHORE**

**COURSES & SYLLABI
PhD APPLIED GEOLOGY (ENGINEERING GEOLOGY)**

DURATION: 01 YEAR (2 SEMESTERS) FOR COURSE WORK

COURSE WORK: 18 CREDIT HRS

Course Code	Course Title	Credit hrs
GEOL-741	Geomechanics	03
GEOL-742	Slope Stability: Types, Factors And Investigations	03
GEOL-743	Mine Geology: Investigations & Exploration	03
GEOL-744	Slope Stability: Evaluations And Mitigations	03
GEOL-745	3D Geological Modeling	03
GEOL-746	Underground Excavations & Support Assessment	03
GEOL-747	Numerical Methods In Geomechanics	03
GEOL-748	Mine Geology: Data Analysis & Resource Estimation	03
GEOL-749	Mine Geology: Surface And Subsurface Mining	03
GEOL-750	Slope Stability Hazard Zonation	03
GEOL-751	Geohazards; Types And Factors	03
GEOL-752	Geohazards; Zonation & Risk Assessment	03
GEOL-753	Foundation Analyses And Design	03
GEOL-754	Engineering Geology In Dams & Hydropower Projects	03
GEOL-755	Seismicity And Seismotectonics Of Pakistan	03
GEOL-756	Geo Materials: Suitability Criteria	03
GEOL-757	Construction Materials For Dams & Hydropower Projects	03
GEOL-758	Construction Materials For Roads & Highways	03
GEOL-759	Rock Blasting	03

GEOL-741 GEOMECHANICS

Introduction to rock engineering including the engineering description of rocks, discontinuities and rock mass; the strength of rock substance, defects and rock mass; laboratory testing of rock, defect surveys, data presentation and hemispherical projections, Site investigations, rock mass classification systems, excavatability of rocks, role and application of reinforcement systems, geotechnical instrumentation, stress analysis and stability evaluation around complex excavations, ground control management and environmental geomechanics.

Referred Books

1. Brady, B H G; Brown, E T (2006) Rock Mechanics for Underground Mining, Springer, 3rd Edition,
2. Hoek, E; Brown, E T (1980) Underground Excavations in Rock, IMM, 1st Edition.
3. Hoek, E; Kaiser, P K; Bawden, W F (1997) Support of Underground Excavations in Hard Rock, A ABalkema, 1st Edition,.
4. Jaeger, J.C., Cook, N.G.W, Zimmerman, R.W. (2007). Fundamentals of Rock Mechanics, Blackwell Publishing, 4th Edition.
5. Hudson, J A; Harrison, JP (1997) Engineering Rock Mechanics: An Introduction to the Principles, Elsevier, 1st Edition,
6. Muir Wood, D (2004) Geotechnical Modelling, Spon Press, 1st Edition.
7. Wyllie, D C; Mah, C W (2004) Rock Slope Engineering, Spon Press, 1st Edition.

GEOL-742 SLOPE STABILITY: TYPES, FACTORS AND INVESTIGATIONS

Landslide classification and recognition; relation to topography and geology. Earthquake induced landslides, Rain Induced landslides, and site investigations for landslides – the specific issues with respect to Pakistan.

Referred Books

1. Brunsden, Denys. , Prior, David B; Slope instability; Wiley, 1984.
2. Cornforth, Derek; Landslides in practice: investigations, analysis, and remedial/preventive options in soils; J. Wiley, 2005.
3. Schumm, Stanley Alfred; The fluvial system; Wiley, 1977.
4. Turner, A. Keith , Schuster, Robert L; Landslides : investigation and mitigation; National Academy Press, 1996.
5. Brunsden, D. and Prior, D., eds. 1984. Slope Instability. John Wiley & Sons, New York.
6. Burbank, D.W. and Anderson, R.S. 2001. Tectonic Geomorphology. Blackwell Science.
7. Cornforth, D H (2005) Landslides in Practice. John Wiley & Sons, New Jersey.
8. Panizza, M. 1996. Environmental Geomorphology. Elsevier, Amsterdam.
9. Schumm, S.A. 1973. The Fluvial System. John Wiley & Sons, New York.
10. Turner, A K; Schuster, R L (1996) Landslides – Investigation and Mitigation. TRB Special Publication 247, Transportation Research Board.

GEOL-743 MINE GEOLOGY: INVESTIGATIONS & EXPLORATION

Surface and subsurface investigations methods, geological mapping, geophysical tools and methods including 2D and 3D seismic, microseismics, tomography, electromagnetic imaging techniques, radar and down-hole survey for the exploration of geology/ minerals. Necessary laboratory testing, Analysis of the surface and subsurface data to develop interpreted geological model.

Referred Books

1. Frederic H Lahee. (1961) Field Geology
2. Bell. F. G, (2004), Engineering Geology and Construction, CRC Press
3. Waltham. T, 2004, Foundations of Engineering Geology, Third Edition, CRC Press
4. Howard L. Hartman, Jan M. Mutmansky, Introductory Mining Engineering, 2nd Edition
5. Richard H. Gorshong, 2006, JR. 3-D Structural Geology: A Practical Guide to Quantitative Surface and Subsurface Map Interpretation, Springer Berlin Heidelberg New York, 1st Edition
6. Marjoribanks. R, (2010), Geological methods in Mineral Exploration and Mining, Springer New York
7. Syd S. Peng, (2008), Coal Mine Ground Control, 3rd Edition
8. Brady, B H G; Brown, E T (2006) Rock Mechanics for Underground Mining, Springer, 3rd Edition,
9. L. Thomas (2002). Coal Geology, John Wiley & sons.

10. Introduction to Ore Forming Processes by Robb, L., 2005, Blackwell Science LTD
11. Geology of Mineral Deposits by Smirnov, V.I. and Creighton H.C., 2001, New Chand & Bros
12. An Introduction to Economic Geology & its Environmental impact by Evans, A. M., 1997
13. Ore Geology and Industrial Minerals by Evans, A.M., 1993, Blackwell Publishers
14. Ores and Minerals by Barnes, J. W., 1988, Open University Press
15. Metal Deposits in Relation to Plate Tectonics by Sawkins, F.J., 1984, Springer-Verlag, New York.
16. An Introduction to Ore Geology by Evans, A. M., 1987, Blackwell Scientific
17. Ore Deposit Geology by Edward, R. and Atkinsons, K., 1986, Chapman and Hall
18. Mineral Deposits and Global Tectonic Setting by Mitchell, A.H.G. and Garson, M.S., 1981, Academic Press
19. Selected research papers

GEOL-744 SLOPE STABILITY: EVALUATIONS AND MITIGATIONS

Analysis of stability; selection of shear strengths, review of limit equilibrium analysis, back-analysis; slope stabilization, pre failure deformations of soil slopes. Rock slope stability analysis including stereographic methods for planar, wedge and toppling modes. Probabilistic methods in rock slope stability analysis. Slope stabilization techniques including geometry change, control of piezometric pressures, anchoring, retaining walls, reinforced soil. Design of slopes in soft clay, including pre-loading, wick drains. Rock slope stabilization by anchors, bolts, cables, and drainage. Pre and post failure deformations of excavated rock slopes. Case histories with respect to Pakistan

Referred Books

1. Brunsdon, D. and Prior, D., eds. 1984. Slope Instability. John Wiley & Sons, New York.
2. Burbank, D.W. and Anderson, R.S. 2001. Tectonic Geomorphology. Blackwell Science.
3. Cornforth, D H (2005) Landslides in Practice. John Wiley & Sons, New Jersey.
4. Panizza, M. 1996. Environmental Geomorphology. Elsevier, Amsterdam.
5. Schumm, S.A. 1973. The Fluvial System. John Wiley & Sons, New York.
6. Turner, A K; Schuster, R L (1996) Landslides – Investigation and Mitigation. TRB Special Publication 247, Transportation Research Board.
7. Brunsdon, Denys. , Prior, David B; Slope instability; Wiley, 1984.
8. Cornforth, Derek; Landslides in practice: investigations, analysis, and remedial/preventive options in soils; J. Wiley, 2005.
9. Schumm, Stanley Alfred; The fluvial system; Wiley, 1977.
10. Turner, A. Keith , Schuster, Robert L; Landslides : investigation and mitigation; National Academy Press, 1996.

GEOL-745 3D GEOLOGICAL MODELLING

Introduction to scripting, gridding algorithms, constructing 3D geological computer models of subsurface geology geotechnics, aquifers, mineral deposits and reservoirs, gridding of faulted and folded geological data, geostatistical simulation, facies modelling, and calculating the volume of a resource (water, ore, oil and gas). geological structure and environmental effects including; stress, valley bulging, tectonic setting, glaciation, weathering and alteration; and Holocene geology. Geomorphology, the surface expression of the underlying geology and geological processes. Total geology and geotechnical engineering models based on surface and subsurface data. Planning of site investigations and the parameters required, drilling, trenching and in-situ permeability of soil and rock. engineering geological mapping. Preparation of multiple geological, structural, geotechnical, geomorphological and landslides maps from the interpreted 3D model.

Referred Books

1. K. E. Zakrevsky (2011), Geological 3D Modelling, EAGE Publications
2. S. Houlding (1994), 3D Geoscience Modeling, Springer-Verlag
3. Forster. A, Merriam. D. F, (1996). Geologic modeling and mapping, Plenum Press
4. D. G. Price & M. Freitas (2009). Engineering Geology, Principles and Practice, Springer
5. T. Waltham (2002). Foundations of Engineering Geology, Spon Press
6. D. F. Merriam & J. C. Davis (2001). Geologic Modeling and Simulation, Plenum Publishers, 1st edition
7. R. Marjoribanks (2010), Geological methods in Mineral Exploration and Mining, Springer New York

GEOL-746 UNDERGROUND EXCAVATIONS & SUPPORT ASSESSMENT

Stress in rock and the effect of depth on pre-excavation stress state; other factors influencing stress in rock; excavation-induced stress and the rock mass response to excavation process; stress distributions around different excavation shapes and sizes - elastic and inelastic rock materials; excavation stability and potential failure modes; interaction between different excavations (horizontal and vertical interaction); effect of time on rock behaviour around excavations. Rock mass classification systems for the prediction of support requirements, including NATM; design of support elements including bolts, dowels, mesh and anchors. Measurement of in-situ stresses; instrumentation and monitoring; squeezing and swelling ground. Underground excavation methods and their applicability.

Referred Books

1. Brady, B H G; Brown, E T (2006) Rock Mechanics for Underground Mining, Springer, 3rd Edition,
2. Hoek, E; Brown, E T (1980) Underground Excavations in Rock, IMM, 1st Edition.
3. Hoek, E; Kaiser, P K; Bawden, W F (1997) Support of Underground Excavations in Hard Rock, A ABalkema, 1st Edition,.
4. Jaeger, J.C., Cook, N.G.W, Zimmerman, R.W. (2007). Fundamentals of Rock Mechanics, Blackwell Publishing, 4th Edition.
5. Hudson, J A; Harrison, JP (1997) Engineering Rock Mechanics: An Introduction to the Principles, Elsevier, 1st Edition,
6. Muir Wood, D (2004) Geotechnical Modelling, Spon Press, 1st Edition.
7. Wyllie, D C; Mah, C W (2004) Rock Slope Engineering, Spon Press, 1st Edition.

GEOL-747 NUMERICAL METHODS IN GEOMECHANICS

Introduction to finite element methods. Mathematical formulation of finite elements. Isotropic elements. Linear and nonlinear analysis. Steady state and transient field problems – heat conduction, seepage etc., coupled analysis, consolidation analysis, solute transport problems, special topics: infinite elements, double porous media

Referred Books

1. Comprehensive Rock Engineering, Vol. 1-5. Hudson
2. J. B. Martins (1982). Numerical Methods in Geomechanics, Reidel Publishing Company
3. G. Swoboda (1988). Numerical Methods in Geomechanics, 6th Edition, Pennsylvania State University
4. D. Billiaux, C. Detournay, R. Hart, X. Rachez, (2003). FLAC and Numerical Modeling in geomechanics, A.A. Balkema Publisher Tokyo
5. Wyllie, D, Mah, C, (2004). Rock Slope Engineering, 4th Edition, CRC Press
6. Selected Research papers from various journals

GEOL-748 MINE GEOLOGY: DATA ANALYSIS & RESOURCE ESTIMATION

Statistical analysis of sampling data, geologic interpretation and deposit models, mineral resources estimation approaches and methods including polygonal estimation, nearest neighbour estimation, triangular estimation, contour estimation, method of sections (plans) estimation, inverse distance estimation, and ordinary kriging estimation. Geostatistical concepts of mineral deposit estimation, Geological influences on deposit estimation. Theory and properties of kriging in practice, In situ resource estimation, classification of resources and reserves. Basic resource/reserve reporting with particular reference to the international standards/ practices.

Referred Books

1. Comprehensive Rock Engineering, Vol. 1-5. Hudson
2. Bell, F. G, (2004), Engineering Geology and Construction, CRC Press
3. Rendu, J. M, 2008, Introduction to Cut-off Grade Estimation, Society for Mining, Metallurgy, and Exploration
4. Price, D. G, Freitas, M, 2009 Engineering Geology, Principles and Practice, Springer
5. Howard L. Hartman, Jan M. Mutmansky, Introductory Mining Engineering, 2nd Edition
6. Ian C. Runge, 1998, Mining Economics and Strategy, Society for Mining, Metallurgy, and Exploration
7. Marjoribanks, R, 2010, Geological methods in Mineral Exploration and Mining, Springer New York
8. Mining Geology by Mckinstry, H.B., latest Ed., Prentice Hall.

9. Exploration and mining Geology by Peters, W.E., latest Ed., John Wiley & Sons.
10. Techniques in Mineral Exploration by Reedman, J.H., latest Ed., ASP.
11. Introduction to Ore Forming Processes by Robb, L., 2005, Blackwell Science LTD
12. Geology of Mineral Deposits by Smirnov, V.I. and Creighton H.C., 2001, New Chand & Bros
13. An Introduction to Economic Geology & its Environmental impact by Evans, A. M., 1997
14. Ore Geology and Industrial Minerals by Evans, A.M., 1993, Blackwell Publishers
15. Ores and Minerals by Barnes, J. W., 1988, Open University Press
16. Metal Deposits in Relation to Plate Tectonics by Sawkins, F.J., 1984, Springer-Verlag, New York.
17. An Introduction to Ore Geology by Evans, A. M., 1987, Blackwell Scientific
18. Ore Deposit Geology by Edward, R. and Atkinsons, K., 1986, Chapman and Hall
19. Mineral Deposits and Global Tectonic Setting by Mitchell, A.H.G. and Garson, M.S., 1981, Academic Press
20. Selected Research papers from various journals

GEOL-749 MINE GEOLOGY: SURFACE AND SUBSURFACE MINING

Interaction between geology (engineering geology, structural geology and applied geophysics) and mining engineering in the geotechnical field. Surface and underground mining methods, Affect of engineering geology and groundwater on surface mining slope stability for discontinuities, variable materials and pore pressures; effect of excavation method and scheduling in pit stability. Range of underground (coal) mining methods used in and the core geotechnical parameters and criteria that effect the choice or application of the methods. Mine entry systems (drifts, shafts etc); mine subsidence mechanics.

Referred Books

1. Howard L. Hartman, Jan M. Mutmansky Brady (2002). Introductory Mining Engineering. John Wiley & Sons.
2. Hartman (2007). Introductory Mining Engineering. Wiley India Pvt. Limited
3. B H G; Brown, E T (2006) Rock Mechanics for Underground Mining, Springer, 3rd Edition,
4. Hoek, E; Brown, E T (1980) Underground Excavations in Rock, IMM, 1st Edition.
5. Hoek, E; Kaiser, P K; Bawden, W F (1997) Support of Underground Excavations in Hard Rock, A ABalkema, 1st Edition,.
6. Jaeger, J.C., Cook, N.G.W, Zimmerman, R.W. (2007). Fundamentals of Rock Mechanics, Blackwell Publishing, 4th Edition.
7. Hudson, J A; Harrison, JP (1997) Engineering Rock Mechanics: An Introduction to the Principles, Elsevier, 1st Edition,
8. Muir Wood, D (2004) Geotechnical Modelling, Spon Press, 1st Edition.
9. Wyllie, D C; Mah, C W (2004) Rock Slope Engineering, Spon Press, 1st Edition.
10. Comprehensive Rock Engineering, Vol. 1-5. Hudson
11. Selected research papers.

GEOL-750 SLOPE STABILITY HAZARD ZONATION

Slope stability hazard zonation parameters (slope geometry, materials, topography, drainage, climate, seismicity, human activity, vegetation, etc.) and criteria, Engineering geological mapping, hazard zonation mapping, types of maps and their criteria, maps for landslide-zonation, landslide and debris flow zonation, Use of remote sensing/ GIS in zonation and landuse and review of hazard matrices for unstable slopes.

Referred Books

1. Cornforth D. H, 2005, Landslide in practice, Jhonwiley& sons Inc. New Jercey.
2. Turner, A. Keith , Schuster, Robert L; Landslides : investigation and mitigation; National Academy Press, 1996.
3. Cheng, Y M, Lau, C K, Slope Stability Analysis and Stabilization, Routledge 2008.
4. Clague, J J; Stead, D; Landslides: Types, Mechanisms and Modeling, Cambridge university pess, 2012.
5. Wyllie, D C; Mah, C; Rock Slope Engineering, 4th Edition, Taylor and Francis e-Library 2005
6. Glade, T; Anderson M. G; Crozier, M. J; Landslide Hazard and Risk, Wiley, 2005.
7. Hungr, O; Fell, R; Couture, R.; Eberhardt, E; Landslide Risk Management, Taylor & Francis, 2010.
8. Xie, M; Landslide Hazard: Assessment Using GIS, Alpha Science Int'l Ltd; 1st edition, 2013
9. Selected research papers.

GEOL-751 GEOHAZARDS; TYPES AND FACTORS

Physical and chemical properties of geological media, Hydrogeological characteristics of geological materials, disintegration and transportation processes of geological materials including weathering, leaching, erosion & transportation-sedimentation. Seismic Risk/ Earthquakes (Principles of plate tectonics, and principles of structural geology, seismic risk analysis, seismic zoning, induced earthquakes, etc.) Mass Movements (Soil and rock slope stability, debris flows, mud slides, quick clay, sagging slopes, rock fall, rock avalanches, pre-failure-, failure and post-failure characteristics, prediction techniques for failure, rock fall modeling, prediction of area of influence, reactivation. Subsidence (Subsidence due to ground water withdrawal or mining activities, prediction methods, calculation methods for settlement, prevention methods, karst, etc.).

Referred Books

1. Coch, N; Geohazards: Natural and Human, 1st Edition, Prentice Hall, 1994.
2. Abramson, L. W.; Lee, T. S; Sharma S; Boyce, G. M; Slope Stability and Stabilization Methods, 2nd edition, Wiley, 2001.
3. Cornforth D. H, 2005, Landslide in practice, Jhonwiley & sons Inc. New Jersey.
4. Fenton, G. A; Griffiths, D. V; Risk Assessment in Geotechnical Engineering, Wiley, 2008
5. Wyllie D. C; Mah, C; Rock Slope Engineering, 4th Edition, 2004, CRC Press
6. Koerner, R, M; Designing with Geosynthetics, 6th Edition, 2012, Xlibris Corporation
10. Selected research papers.

GEOL-752 GEOHAZARDS: ZONATION AND RISK ASSESSMENT

Introduction to the concept of hazard zonation and risk, hazard zonation maps, Application of GIS and remote sensing techniques for hazard zonation, image analysis for hazard monitoring, susceptibility and assessment, spatial modelling of hazards, mapping of elements at risk, risk assessment criteria, risk assessment and management pertaining to Geohazards (principle of risk management, risk assessment, qualitative approach, quantitative method, etc.). Risk avoidance and minimization; financial risk, portfolio theory, risk sharing and financing; ambient and acceptable risk levels. Case Studies with respect to Pakistan.

Referred Books

1. Coch, N; Geohazards: Natural and Human, 1st Edition, Prentice Hall, 1994.
2. Cornforth D. H, 2005, Landslide in practice, Jhonwiley & sons Inc. New Jersey.
3. Fenton, G. A; Griffiths, D. V; Risk Assessment in Geotechnical Engineering, Wiley, 2008
4. Wyllie D. C; Mah, C; Rock Slope Engineering, 4th Edition, 2004, CRC Press
5. Thomas H. Meye, Introduction to Geometrical and Physical Geodesy: Foundations of Geomatics, Esri Press, 2010
6. George Korte, GIS Book, OnWord Press, 5th edition, 2000.
7. Tate, N, Atkinson, P. M, Modelling Scale in Geographical Information Science, Wiley, 1st edition, 2001
8. Oka, F; Murakami, A; Kimoto, S; Prediction and Simulation Methods for Geohazard Mitigation, CRC Press, 1st edition, 2009
9. Selected research papers.

GEOL-753 FOUNDATION ANALYSES AND DESIGN

Principles of foundation types and design. Shallow foundations – general bearing capacity equations for vertical and inclined loads, settlement calculations, foundations in sand, rock and reactive clays. Earth pressures, retaining structures. Piles – advanced analysis of pile capacity, group analysis, lateral loading, dynamic integrity testing and analysis settlement analysis. Cast in-situ piles, sheet piles, diaphragm walls, anchored and strutted walls, – analysis and construction methods. Analysis of soil nailing and anchors in excavations.

Referred Books

1. Beavis, F.C., (1985), Engineering Geology, Blackwell Scientific Publications.
2. Bolton, Malcolm (1991). A Guide to Soil Mechanics, M.D. & K. Bolton.
3. Bowles, J.E. (1991). "Physical and Geotechnical Properties of Soils" McGraw-Hill Book Co.
4. Braja Das, (2007). Principles of Foundation Engineering, sixth edition, Thomson, Toronto, Canada.
5. Braja M. Das, (2002). Principles of Geotechnical Engineering, fifth Edition, Thomson.

6. Capper, P.L. & Cassive W.E. & Geddes, J.D., (1966), Problems in Engineering Soil, Latest Ed., John Wiley & Sons
7. Das, B.M. (1998). "Principles of Geotechnical Engineering" Fourth Edition, PWS Publishing Co.
8. Duncan, N (1968). Engineering Geology and Rock Mechanics, Leonar Hill.
9. Jumikis, Alfred R., (1962). Soil Mechanics, Princeton, New Jersey: D. Van Nostrand Company, Inc.
10. Taylor, Donald W., (1949). Fundamentals of Soil Mechanics, John Wiley & Sons.
11. Terzaghi, Karl, Soil Mechanics in Engineering Practice by
12. Tuma, Jan J. and M. Abdel Haddy (1977). Engineering Soil Mechanics, Prentice Hall.
13. Selected research papers

GEOL-754 ENGINEERING GEOLOGY IN DAMS & HYDROPOWER PROJECTS

Site investigations planning, and techniques for dams and hydropower projects, types of dam structures and suitability in relation to geological conditions, development of geological and geotechnical models for main structures, insitu testing in soil and rocks, rock characterization and classification, excavatability of rocks, derivation of rock mass parameters, permeability of insitu soils and rocks, Types and design of infill grouting and other seepage control measures, Foundation preparation, cleanup and grouting. Preparation of specification and quality control.

Referred Books

1. Brady, B H G; Brown, E T (2006) Rock Mechanics for Underground Mining, Springer, 3rd Edition,
2. Hoek, E; Brown, E T (1980) Underground Excavations in Rock, IMM, 1st Edition.
3. Hoek, E; Kaiser, P K; Bawden, W F (1997) Support of Underground Excavations in Hard Rock, A ABalkema, 1st Edition,.
4. Jaeger, J.C., Cook, N.G.W, Zimmerman, R.W. (2007). Fundamentals of Rock Mechanics, Blackwell Publishing, 4th Edition.
5. Hudson, J A; Harrison, JP (1997) Engineering Rock Mechanics: An Introduction to the Principles, Elsevier, 1st Edition,
6. Muir Wood, D (2004) Geotechnical Modelling, Spon Press, 1st Edition.
7. Wyllie, D C; Mah, C W (2004) Rock Slope Engineering, Spon Press, 1st Edition.

GEOL-755 SEISMICITY AND SEISMOTECTONICS OF PAKISTAN

Seismology and interior of earth, progress of seismology. Application of seismology. Global mosaic of earthquakes, earthquake effects, depth of earthquake, tectonic pattern, types of seismic waves in earthquake shaking. Causes of earthquakes, size of an earthquake, Stimulation of earthquake by water. Seismicity related with different plate boundaries; Convergent plate boundary, divergent plate boundary, transforms plate boundary and intraplate setting.

Seismicity and tectonics; thin skinned tectonics, thick-skinned tectonics and flake tectonics. Seismotectonics of Himalayas, Hindukush, etc. Damage observations and earthquake intensity. Determination of focal depth, location of epicenter, earthquake source mechanism and fault plane solution, seismicity and seismic zoning maps, earthquake prediction and modification, seismic site investigation and surveillance, model test in earthquake engineering.

Seismotectonic study for engineering structures, Nuclear Plants, Highways, Dams, Bridges, Buildings, Waste disposal and slope instability.

Referred Books

1. Active tectonics. National Academy press Washington, USA., 1986.
2. Engineering Seismology by Agrawal, P.N., 1991. Oxford and IBH publisher company, New Delhi.
3. An introduction to seismological research history and development by Benjamin, Howell, J.K., 1990., Cambridge University Press.
4. Earthquake a primer by Boit, B.A., 1978, W.H. Freeman and company, San Francisco.
5. Geodynamics of Pakistan by Farah, A., and Dejong, K.A., 1979. Geological Survey of Pakistan, Quetta.
6. Zagros-Hindukush-Himalaya, Geodynamic Evolution by Gupta, H.D., and Delancy, F.M., 1981. Geodynamic series vol., 3. American Geophysical Union Washington, D.C., Geological Society of America Boulder Colorado, USA.
7. Tectonics of the Western Himalayas by Malinconico, L.L., and Lillie, R;J., 1989, special paper, 232 Geological Society of America Colorado, USA.

8. Geological Structures and moving plates by Park, R.G., 1988, Chapman and Hall publisher, New York, 337p.
9. Geology of Earthquakes by Roberts S. Yeats, 1997, Oxford University Press.
10. Elementary Seismology by Richter, C.F., 1958, W.H Freeman and company San Francisco and London.
11. Geophysical method in Geology by Sherma, P.V., 1986 Elsevier, New York, Amsterdam and London, 442p.
12. Neotectonics of North America by Slemmons, D.B., Engdahl, E.R., Zoback, D. & Blackwell, D.D., Geological Society of America Colorado USA.
13. Gravity Field Seismicity and Tectonics of the Indian Peninsula and the Himalayas by Verma, R.K., 1985., Allied Publishers.
14. Geodynamics of the Indian Peninsula and the Indian Plate margin by Verma, R.K, 1991, Oxford and IBH publication company, New Delhi.
15. Physical geology exploring the earth by Wincander, R., 2001, A division of Thomson Learning Canada,
16. The evolving continents, Second edition, by Windlay, B.F., 1982, John Wiley and Sons, New York.

GEOL-756 GEO MATERIALS: SUITABILITY CRITERIA

The types of natural occurring materials and their properties. Uses of rock and soil as construction materials. Suitability criteria of geomaterials according to international standards (ASTM, AASHTO, etc). Necessary laboratory testing for suitability. Application in civil engineering projects. Qualitative and quantitative assessment criteria.

Referred Books

1. Domone & Illston (2010). Construction Materials: Their nature and behaviour. 4th ed. Spohn Press.
2. E. Amsterdam (2000). Construction materials for Civil Engineering. Juta & Co. Ltd.
3. Mamlouk & Zaniewski (2011). Materials for Civil and Construction Engineers. Pearson Education, Limited.
4. Collins, L and Smith, M.R (1993). Aggregates. Geological Society of London, Special publication No. 09.
5. Neville, A.M. (2000) Properties of concrete, Longman, U.K, 4th Edition, pp 1-844.
6. Swamy, R.N. (1992). The Alkali-silica reactions in concrete, the Blackie publishing Group, Bishopbriggs, Scotland, cements and Concrete composition, volume 14, Issue 1, pp 72-74.
7. Selected Research papers

GEOL-757 CONSTRUCTION MATERIALS FOR DAMS & HYDROPOWER PROJECTS

Properties and usage of soil and rock as construction materials for various dam types. Selection and characterization of construction material for concrete gravity dams, rock fill dams & earth fill dam.

Referred Books

1. E. Amsterdam (2000). Construction materials for Civil Engineering. Juta & Co. Ltd.
2. Mamlouk & Zaniewski (2011). Materials for Civil and Construction Engineers. Pearson Education, Limited.
3. Domone & Illston (2010). Construction Materials: Their nature and behaviour. 4th ed. Spohn Press.
4. Geological Society of London (2006). Clay materials used in construction. Geological Society of London.
5. C. Krutzner (1997). Earth & Rock fill dams: Design and construction. A.A. Balkema
6. R. B. Jansen- ed. (1988). Advanced Dam Engineering for Design, Construction, and Rehabilitation
7. Collins, L and Smith, M.R (1993). Aggregates. Geological Society of London, Special publication No. 09, pp. 339
8. Neville, A.M. (2000) Properties of concrete, Longman, U.K, 4th Edition, pp 1-844.
9. Swamy, R.N. (1992). The Alkali-silica reactions in concrete, the Blackie publishing Group, Bishopbriggs, Scotland, cements and Concrete composition, volume 14, Issue 1, pp 72-74.
10. Selected Research papers

GEOL-758 CONSTRUCTION MATERIALS FOR ROADS & HIGHWAYS

Properties and usage of soil and rock as pavement materials. Selection and characterization of subgrade, sub-base and base materials. Properties and usage of bitumen, and asphalts. Polymers and other additives. Manufacture and use of bituminous concrete. Mix design. Sprayed seals. Concrete for rigid pavements and sub-bases. Types of pavement, selection on basis of cost and performance. Sub-grade conditions, working platforms. Role of environmental factors including temperature and moisture. Soil moisture equilibria and drainage requirements. Prediction and characterisation of traffic loadings. Stress distribution in flexible and rigid pavements. Computer-based and approximate methods of analysis. Principles of mechanistic design. Comparative evaluation of design criteria and design procedures for flexible and rigid pavements for roads. Stabilisation using cement, lime and bitumen. Types of pavement distress, their origins and remedy. Evaluation and prediction of pavement condition. Pavement instrumentation and monitoring. Measurement and report of physical distress including cracking, rutting and roughness. Pavement maintenance for flexible and rigid pavements. Over-lays and membranes. Recycling. Maintenance scheduling and management.

Referred Books

1. Collins, L and Smith, M.R (1993). Aggregates. Geological Society of London, Special publication No. 09, pp. 339
2. Domone & Illston (2010). Construction Materials: Their nature and behaviour. 4th ed. Spopn Press.
3. E. Amersterdam (2000). Construction materials for Civil Engineering. Juta & Co. Ltd.
4. Mamlouk & Zaniewski (2011). Materials for Civil and Construction Engineers. Pearson Education, Limited.
5. Neville, A.M. (2000) Properties of concrete, Longman, U.K, 4th Edition, pp 1-844.
6. Swamy, R.N. (1992). The Alkali-silica reactions in concrete, the Blackie publishing Group, Bishopbriggs, Scotland, cements and Concrete composition, volume 14, Issue 1, pp 72-74.
7. Selected Research papers

GEOL-759 ROCK BLASTING

Mechanics and practical applications and current technologies in rock fragmentation; theories of rock breakage and fragmentation; rock mass properties; structure and discontinuities and their impact on blast behaviour. Blasting theories and types of explosives and blast initiation procedures; blast designs for both underground and surface applications; blast hazard management; blast vibration and impact on structures and underground excavations; state-of-the-art blasting practices and technologies; and alternatives to conventional blasting for rock fragmentation.

Referred Books

1. Brady, B H G; Brown, E T (2006) Rock Mechanics for Underground Mining, Springer, 3rd Edition,
2. Hoek, E; Brown, E T (1980) Underground Excavations in Rock, IMM, 1st Edition.
3. Hoek, E; Kaiser, P K; Bawden, W F (1997) Support of Underground Excavations in Hard Rock, A Balkema, 1st Edition,.
4. Jaeger, J.C., Cook, N.G.W, Zimmerman, R.W. (2007). Fundamentals of Rock Mechanics, Blackwell Publishing, 4th Edition.
5. Wyllie, D C; Mah, C W (2004) Rock Slope Engineering, Spon Press, 1st Edition.
6. Hudson, J A; Harrison, JP (1997) Engineering Rock Mechanics: An Introduction to the Principles, Elsevier, 1st Edition,
7. Wyllie, D C; Mah, C W (2004) Rock Slope Engineering, Spon Press, 1st Edition.
8. Morhard, R. C, (1987) Explosives and Rock Blasting, Blasters Tool & Supply Co
9. Persson, A; Holmberg, R; Lee, J (1993) Rock Blasting and Explosives Engineering, CRC Press; 1st edition
10. Jimeno, E. L; Carcedo, A (1995) Drilling and Blasting of Rocks, Taylor & Francis

(Prof. Dr. M. Saeed Farooq)
Director