

B. Tech. in MINING ENGINEERING

Syllabus of Paper – 1

MINE DEVELOPMENT

Introduction to Mining: History of mining, contribution of mining to civilisation and national economy Indian mineral resources and world status, role of mining engineers in industry. Introduction to opencast and underground coal & metalli ferrous mining – selection criteria, comparison. Modes of entry into deposits for underground mining – shafts, inclines, adits, etc. Introduction to Drilling: Principles of drilling, methods, selection, applications and limitations, drill bits, flushing methods, fields of application, exploration and production drilling, drilling in underground workings, variables affecting the performance of drilling, novel methods of drilling. Introduction to Explosives and Blasting : Types of explosives, fuses, detonators and other accessories, alternatives to explosives, cause of accidents and safety precautions, drilling and blasting pattern for underground excavations, merits, demerits and limitations of blasting. Shaft Sinking : Selection of site and size, sinking methods, support system, ventilation, lighting and drainage arrangements during sinking, material handling and safety in sinking shafts. Introduction to piling, caisson and freezing methods - cementation method - widening and deepening of shafts. Modern techniques of shaft sinking – shaft boring, design of shaft insets, pit bottom excavation and shaft raising. Drifting and Tunneling: Drivage of drifts, organisation and cycle of operations, supporting of development workings, modern methods of drifting, tunnelling, road heading and tunnel boring.

GEOLOGY – I

Physical Geology : Geology in mining engineering : scope and applications – earth structure and composition– weathering processes and grades – groundwater : origin, occurrence and exploration techniques. Stratigraphy: Geological time scale – mineral resource distributions and economic importance of Archean, Paleozoic, Mesozoic and Cenozoic rocks of India. Mineralogy & Petrology: Classification of minerals – Physical properties of minerals – Properties of quartz, feldspar, pyroxene, amphibole, mica, olivine and garnet group of minerals and calcite. Classification of rocks – Description of igneous, sedimentary and metamorphic rocks – forms and mode of occurrence of rocks – Engineering properties of rocks: field and laboratory tests. Structural Geology: Introduction to geological structures – folds, faults, joints and unconformities– classification, criteria for recognition in the field and significance in mineral exploration. Determination of strata thickness. Dip and strike calculations. Economic Geology : Ore forming processes, mineral deposits formed from magnetic, hydrothermal and volcanic processes; Mechanical concentration, oxidation and supergene enrichment. Origin and occurrence of Indian economic mineral deposits.

ENGINEERING SURVEYING

Introduction and Linear Measurements: Objectives and general principles of mine surveying, definitions of plane and geodetic surveying, Chain surveying, principles, equipment, ranging, setting and chain lines, chaining on sloping ground, errors in chaining, use of steel tape and corrections, corrections to measured lengths, errors in measurement, miscellaneous field problems relating to sighting, taping and both, field notes, record of data, plotting and computation. Angular Measurement : Construction, testing, correction/adjustments of angle-measuring instruments-theodolite, compass, angle measurement procedures, corrections, and computations,

plane and rectangular coordinates, relative applications, sources of error and field checks in traversing, relative merits and applications of theodolite, fixed, free needle surveying, etc., limit of precision. Levelling: Construction, testing and adjustment of leveling instruments methods of leveling, rise and fall, height of collimation, booking, errors, computations, standards of accuracy. Triangulation: Primary, secondary, tertiary triangulation, frame work of triangles, accuracy required, setting up baseline, extension, main and check base, corrections, angle measurement methods, figure adjustment and correction, computation of triangulation scheme, transfer coordinates through two, three four point interpolation, reduction to centre (satellite station) methods, broken baseline method. True North Fixation and Plane Table Surveying: Common terms and definitions in astronomical surveys – determination of true north, sun/ star observations and connection to triangulation base line. Descriptions of plane table and accessories – alidade, plumbing fork, etc., methods and use of plane table surveying, two and three point problems.

MINE VENTILATION

Mine Gases : Occurrence, properties, physiological effects, detection – types of instruments, construction, principle and limitations, measurement and analysis, methane layering, methane drainage. Mine Climate and Control: Psychrometric properties of air, Sources of heat and humidity in mines and their effects, heat stress estimation, cooling power of mine air and methods of improving cooling power including air conditioning. Psychrometric surveys. Principal Laws of Air Movement and Air Current Distribution in Mines: Fundamentals of fluid flow and its application in mine ventilation with special reference to Bernoulli's Equation, Reynolds number, Poiseuille's equation, Atkinson's equation, Karman-Prandtl equation for rough flows, resistance of mine roadways, friction and shock resistance, etc. Distribution of air current in mines – splitting, stoppings, regulators, ventilation doors, air crossings, controlled recirculation, etc. Retrograde and boundary, ascensional, decensional, homotropical and antitropical ventilation systems, Ventilation in deep and hot mines, remedial measures. Natural Ventilation: Natural ventilation, effect of depth, temperature, pressure, etc. thermodynamic treatment, artificial aids to natural ventilation. Mechanical Ventilation : Main mechanical ventilators, booster fans and auxiliary fans, and their selection, installation, fan performance, characteristics and testing, fans in series and parallel, fan drifts and evasees, reversal of air current, forcing versus exhaust ventilation, ventilation of long headings including overlap systems. Ventilation survey and ventilation planning : Methods of ventilation survey, Instruments required for ventilation survey. Calculation of pressure and quantity requirements, economic analysis, ventilation standards, network analysis, monitoring of mine environment. principles and computer applications.

MINE ECONOMICS AND INVESTMENT

Introduction: Mineral industry and its role in national economy; world and national mineral resources; Mining - A unique investment environment; special risk factors in mine investment and evaluation; national mineral policy. Ore Reserve Estimation: Methods of sampling, sampling frequency; analysis of sampling data, estimation of reserves, introduction to geo-statistical methods, classification of reserves. Mine Valuation: Time value of money; annuity; redemption of capital, net present value; depletion allowance; depreciation; inflation; escalation; rates of return; Hoskold's Two rate method; capital and operating cost including wages, incentives, material, etc.; assets; liabilities; cash flows and discounted cash flow; profitability index – their implications in mine economic evaluation. Project Appraisal: Methods of project evaluation – pay back, annual value, benefit/cost ratio, ERR and IRR, etc., evaluation of exploratory mining areas and operating mines; mine project financing, its risks and constraints; mine taxation; critical impact of depreciation, depletion, type of funding, reserves, life, etc., on mine profitability. Finance and

Accounting: Sources of mine funds – shares, debentures, fixed deposit, sinking fund, capital gearing, P & L account, balance sheet, typical case studies of mine feasibility. Cost estimation of individual mining operations and overall mining cost, cost control methods.

MINE HAZARDS, RESCUE & RECOVERY

Spontaneous Heating and Mine Fires: Causes, detection, incubation period, precautions against spontaneous heating in underground and surface coalmines including coal benches, surface coal stocks, and dumps. Detection, prevention and control of underground fires, fire fighting, study of atmosphere behind sealed-off fire areas for reopening, methods of reopening sealed off fire areas. Explosions: Causes, prevention and control of underground fire-damp and coal dust explosions including stone dusting, stone dust barriers, water barriers and triggered barriers, investigation after an explosion. Mine Rescue and First Aid: Classification of rescue apparatus including self rescuer, various types of rescue and escape apparatus, rescue organisation of a mining company, layout of a modern rescue station including personnel, first aid to the persons injured in mine-accidents, electric shock, asphyxiation, different methods of artificial respiration, rescue and recovery work in mines including through boreholes, rescue rules. Inundation: Surface and underground inundation, their causes and preventive measures, precautions to be taken while approaching old waterlogged workings, safety boring apparatus, design and construction of water dams and barriers, recovery of flooded mines, dewatering of old workings, layout of drainage systems and sumps. Mine Illumination: Electric safety lamps, their maintenance and examination, lamp room design and organisation, lighting from mains, lighting on mechanised longwall faces and gassy mines, photometry and illumination survey, legislations related to illumination survey.

MINE PLANNING AND DESIGN

Introduction : Technical factors in mine planning, methodology of mine planning, short range & long range, mine modelling, mine simulation systems approach to mine planning based on mine sub-system and their elements, mine plan generation. Opencast Mining: Selection of initial mine cuts, location of surface structures, division of mining area into blocks, mine design, bench drainage, geometry, haul roads, slope stability; open pit limits and optimisation, calendar plan, production planning, production scheduling, economic productivity indices. Underground Mining : Location of mine entries, mine and auxiliary, optimisation of mine parameters, design of shaft pillars and protective pillars, planning of production capacity, layout of development drives / raises / winzes etc, length of faces, size of panels, etc, planning of support systems, ventilation, lay out of drainage system, planning production schedule and monitoring, selection of depillaring / stoping method, manpower management economic/ productivity indices, techno-economic analysis, mine reclamation design. Equipment Planning: Latest technological developments in increase in both types and capacities of equipment used in mining operations. Planning and selection of equipment for different mining conditions. Equipment design for optimum drilling and blasting operations. Equipment information – performance monitoring and expert systems, Innovative mining systems. Project Implementation and Monitoring: Pre-project activities – feasibility report, environment clearance, detailed project, report, sources of funds, import of technology, selection of contracts and contract administration, time management, cost control material management system, project quality assurance, social responsibility, government orders and guidelines. Environmental impact assessment and preparation of environmental management plan. Mine closure plan.

MINE LEGISLATION AND SAFETY

Introduction to Mining Laws and Legislation: General principles of mining laws, development of mining legislation of India. Acts, Rules And Regulations – I: Mines Act, Mines Rules, Coal and metalliferous mines Regulations, Bye-laws, Circulars and standing orders. Acts Rules and Regulations – II: Indian electricity rules, coalmines conservation and development act, Workman's compensation act., General provisions of Mines and Minerals Regulation and Development Act, Mineral Concession Rules, Vocational Training .Rules, Crèche rules, Maternity benefit act, Payment of Wages Act, Rescue Rules, Factory Act. Accidents and Diseases: Classification of accidents, causes and prevention of accidents, accident enquiry reports, cost of accidents, occupational diseases and their social effects. Mine Safety: Role of management, labour and government, Safety audit, instrumentation, organisation for disaster management in mines, safety conferences.

Syllabus of Paper – 2

STRENGTH OF MATERIALS

Stress, Strain and Deformation of Solids: Rigid bodies and deformable solids – Tension, Compression and Shear Stresses–Deformation of simple and compound bars – Thermal stresses – Elastic constants–Volumetric strains – Stresses on inclined planes – principal stresses and principal planes – Mohr's circle of stress. Transverse Loading on Beams and Stresses in Beam: Beams – types transverse loading on beams – Shear force and bending moment in beams – Cantilevers – Simply supported beams and over – hanging beams. Theory of simple bending – bending stress distribution – Load carrying capacity – Proportioning of sections – Flitched beams – Shear stress distribution. Torsion: Torsion formulation stresses and deformation in circular and hollow shafts – Stepped shafts – Deflection in shafts fixed at the both ends – Stresses in helical springs– Deflection of helical springs, carriage springs. Deflection of Beams: Double Integration method – Macaulay's method – Area moment Theorems for computation of slopes and deflections in beams - Conjugate beam and strain energy– Maxwell's reciprocal theorems. Thin Cylinders, Spheres and Thick Cylinders: Stresses in thin cylindrical shell due to internal pressure circumferential and longitudinal stresses and deformation in thin cylinders – spherical shells subjected to internal pressure – Deformation in spherical shells – Lamé's theory – Application of theories of failure.

MINING MACHINERY

Introduction: Different types of motive power used in mines – their fields of application, relative merits and demerits; transmission and distribution of compressed air in mines, compressed air drills. Elements of the transport system, classification and techno-economic indices. Rope Haulage: Wire ropes – classification, construction, fields of application, rope capping and splicing; deterioration of rope in use and its prevention; testing of ropes, selection and maintenance, rope calculations. Rail Track and tubs– gauge; layout, curves, turnouts and cross-over, track maintenance, main features of rolling stock like tubs, mine cars man riding cars and tipplers; Types of rope haulages – merits, demerits and fields of application, constructional features, safety appliances and rope haulage calculations. Other Transport Systems: Locomotives – diesel, trolley-wire, battery locomotives, constructional features and safety devices and comparison of different types; underground and surface battery charging stations and safety measures, locomotive calculations; shuttle cars, underground trucks, load-haul-dumpers, SDL vehicles, aerial rope ways, gravity transport, principles of hydraulic & pneumatic transportation and their fields of application, electric layouts, man-riding systems. Pumping: Different types of drives, installation and maintenance of pumps and pipes in shafts and roadways, electrical layouts, various sources of water in mines, design of sumps. Winding Engine & Winding Accessories : Winding systems, drum winders, drives, mechanical braking of winders, safety devices in winding, over wind and over speed protection, Koepe and multi-rope friction winding, electrical layouts. Duty cycles of drum winders of different drum cross sections. Special problems of deep shaft winding. Head gear and their design, head sheave, cages and skips, suspension gear, shaft fittings and appliances – guides, keps, etc., signalling system, winding calculations relating to rope size & numbers, capacity & power requirement for cage, skip, drum and Koepe winding systems.

SURFACE MINING

Introduction: Status of surface mining, types of surface mines, applicability and limitations, compilation of basic data, concept of stripping ratio, stripping economics, concept of ultimate pit limits, design of haul roads, elements of surface mine planning. Layout and Design of Surface Mines: Selection of site for box cut, selection of operating parameters like bench height, width, slope, etc., Working pit slope and ultimate pit slope, various modes of slope failures, factors influencing slope stability, development of opencast mine layouts, stripping methods using different machinery, Various layout problems and their solutions. Conversion of Underground mine to opencast mines. Ground Preparation Methods: Preparation of the site – Ripping, Drilling and Blasting; Types, operation, selection, applications and limitations of ground preparation equipments – Rippers, Dozers, Blast hole drills and rock breakers, Placer mining and hydrolucking. Economics of Drilling and blasting. Excavation System In Surface Mines: Selection criteria for excavation / loading and material transport equipment used in surface mines. Classification, construction, capacity, operation, productivity and application of different types of excavating / loading equipment used in surface mining projects - Shovels, Draglines, Front end loaders, Scrapers, Bucket wheel and bucket chain excavators, Surface miners. Problems of Deep open cast mining. Transport and Waste Dumps: Scope and application of different modes of transport system in surface mines – Trucks, Conveyors (shiftable and high-angle), Aerial ropeways, Rail transport and Pipeline transport systems. Scope and application of in-pit crushers in surface mines. Types of waste dump – internal and external; dump formation methods and corresponding equipment; Dump stability and stabilisation measures.

MINERAL PROCESSING

Introduction: Scope, objectives, minerals/ores for mineral processing, methods of treatment, choice of methods, sequence of operations, product, flow sheets, ore sorting – hand, mechanical, electronic, removal of harmful materials, ore transportation. Comminution: Introduction to comminution, primary/secondary/tertiary crushing, purpose, duty, theory of crushing, crushing sequence, reduction ratio, types of crushers and comparison, general crushing flow sheet, wet/dry grinding, mechanism and various affecting parameters. Laboratory & Industrial Sizing and Sampling and Control: Purpose, factors governing particle behaviour, laboratory and industrial screens, trommels, vibrating screens, etc. wet and dry screening, classification, classifiers. Purpose, sampling - solid ore, pulp, head feed, grinding circuit samples, flotation products, etc., X-ray fluorescence, automatic sampling. Metallurgical accounting. Separation/Concentration: Newton's and Stoke's Laws of particle settlement, different concentration techniques – gravity, chemical, froth flotation, wet & dry magnetic separation, electromagnetic, amalgamation, heavy media, jigging, shaking tables, sluicing, spirals, thickeners, filtration, etc., coal washing. Special Methods: Chemical extraction, cyanide process, leaching, use of ion exchange, solvent extraction, pilot plant studies on ores, tailing dams; generalised plant practice/flow sheets for coal and other important ores – copper, aluminium, lead, zinc, silver, gold, uranium, iron, limestone, magnesite.

ROCK MECHANICS AND GROUND CONTROL – I

Introduction: Definition of some important terms used in rock mechanics, application of rock mechanics in mining, introduction to stress analysis, principal stresses and strains, differential equations of static equilibrium. Physical Properties of Rocks and Rock Indices: Physical properties of rock – density, porosity, moisture content, permeability, swell index, slake durability index, thermal conductivity, hardness, durability, Protodyaknov index, impact strength index, point load index, rock mass classification. Mechanical Properties of Rocks: Preparation of test specimens, laboratory determination of mechanical properties of rocks, compressive

strength, tensile strength, shear strength, modulus of elasticity, Poisson's ratio, triaxial strength of rocks, Mohr's envelope, effect of various parameters on the strength of rocks, in-situ strength, effect of joints and fracture on mechanical properties of rocks. Non-Destructive Testing Methods and Time Dependent Properties of Rocks: Dynamic wave velocities, dynamic elastic constants, their determination in the laboratory, application in mining, time dependent properties of rocks, creep, mechanism of creep of rocks – different stages, rheological models. Underground Supports: Various methods of roof examination, pressure arch theory, ground forces and field stresses, mechanism, objectives and limitations of supports, conventional supports– column type, timber sets, arches, yielding type; rock and cable bolting, rock grouting, shot creting, roof stitching, support of shaft bottoms, galleries, junctions and places of roof falls, design of supports, longwall powered supports. Design of systematic support rules for B & P Development, depillaring LW gate readings and extraction.

UNDERGROUND MINING METHODS – COAL

Introduction : Status of coal industry in India, factors affecting choice of mining methods, classification of mining methods. Bord and Pillar Method-Development : Design and development of a district, bord and pillar, room and pillar methods, with conventional and continuous mining techniques; panel system. Bord and Pillar Method – Extraction : Pillar extraction by caving and stowing methods; mechanised extraction of pillars, shaft pillar extraction, systematic supports, surface, underground and face arrangements for stowing. Longwall Method: Advance and retreat methods, continuous and cyclic systems, extraction with different machines-ploughs, shearers, design of longwall workings, optimum length of face, size of panel, gates, support system, personnel, organisation and safety measures, salvaging in longwall. Special Methods of Working: Problems of working thick & thin seams, multi slices, sublevel caving, horizon mining, gallery blasting method, contiguous seam working, working steeply inclined seams, working under surface structures and seams liable to spontaneous heating, outburst and bumps, etc. hydraulic mining, high wall mining, and shortwall mining, underground coal gasification, shield mining.

ROCK MECHANICS AND GROUND CONTROL – II

Rock Mechanics Instrumentation: Conventional testing machines and servo-controlled stiffness testing machines, load cells, strain gauges, flat jacks, convergence indicators, anchorage testing equipment, sag bolts, etc, in situ measurements. Pit Slope Stability & Subsidence: Approach to slope stability, slope parameters, Geological and physico-mechanical parameters affecting slope stability, effect of water pressure, determination of factor of safety, introduction to methods of failure analysis. Theories of subsidence, factors affecting subsidence, subsidence surveys, subsidence prediction techniques, subsidence control – surface and underground measures, pseudo-mining damage. Theories of Failure of Rocks, Pillar Design: Different theories of failure of rocks, modes of failure - Griffith, Coulumb, Navier, Mohr's, Hoek-Brown, etc. Strength of pillars, barrier and shaft pillars design – load estimation, factor of safety, various formulae, rock burst, bumps. Design of Underground Workings: Stress distribution in underground workings, design of underground openings, measurement of rock movements, engineering rock mass classification, rock load assessment and support design, introduction to numerical methods of geomechanics; scaled model studies – principles of modeling and model material and testing. Stowing/Filling : Principal methods of stowing, collection, preparation and transport of materials, surface, underground and face arrangements, design of stowing plants.

UNDERGROUND MINING METHODS – METAL

Basics: Metal Mining Terminology; Typical modern metal mine features; typical pre stoping ore block constructional features; classification of methods; Techno economic characteristics impacting on choice of method; Typical unit cost parameters; optimum size of mine and stope. General Mine Design : Mode of mine and stope entry; Layouts; optimum production; Basic design – Level Intervals, ore pass, common ore pass, size of blocks ore handling in stope and other openings, overview of constructional features – X cuts, Raises, Winzes etc. Stopping – General Description: Unsupported methods – Room and pillar, shrinkage, sublevel stoping etc. Supported stopes – Cut and fill, square set etc. Caving methods – Top slicing, sublevel caving, block caving. Stope Planning and Layout: Preparing a stoping block; sequence of stoping; organization; production cycle; unit cost calculation; comparison of methods and costs. Novel Innovative Techniques & Special Applications: Rapid excavation; Hydraulic mining; slurry mining; solution mining; Radial – axial splitter; Thermal fragmentation; shock wave breaking; Nuclear mining. Deep mining; narrow contiguous veins; shaft and remnant pillars; VCR; Ring drilling; Large Blast hole stoping. Case studies of Indian and foreign underground metal mines.
