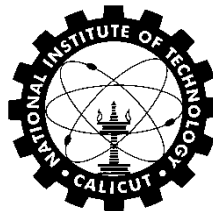# DETAILED SYLLABUS

FOR

Ph.D. COMPREHENSIVE EXAMINATION

तमसो मा ज्योतिर्गमय

Department of Civil Engineering
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT
Kozhikode – 673 601, KERALA, INDIA

TABLE OF CONTENTS

Section A- General Syllabus for Ph D Scholars Comprehensive Examination in Civil Engineering

Total Marks: 40

Part I: English (10 marks)

Word formation – Auxiliary verbs – Modal Verbs – Sentence Types – Affirmative, Negative, Interrogative, Concord – Dialogue.

Tenses – Simple Present, Present Progressive, Present Perfect, Present Perfect Continuous – Voice – Active & Passive – Précis Writing – Essay Writing

Tenses – Simple Past, Past Progressive, Past Perfect, Past perfect continuous – Impersonal Passive.

Tenses – Simple Future, Future progressive, Future Perfect, Future Perfect continuous – Definition – Phrases of Reason – Cause & Effect, Recommendations, Argumentative Essays

Contracted forms, Conditionals, Articles, Preposition, Tense – 'going to' - Error Spotting, Sequence Words – Rearranging – Writing a Book Review – Summary writing – Rearranging Sentences using Sequence Words, Note Making

Stative Verbs, Reported Speech, Clauses and Phrases, Punctuation Marks, Modifiers, Active Voice, Cohesive Devices in Writing, Ambiguous Structures, Relevant styles of citation and indexing, Academic Vocabulary, and Transforming Sentence Structures.

Part II: Statistical Methods (10 Marks)

Sampling design for data collection for a given research problem;

Basic Statistical Tools for Analysis: Summary Statistics, Correlation and Regression, Fitting of simple and Multiple Linear regression, Explanation and Assumptions of Regression Diagnostics.

Statistical inference: probability distributions used in hypothesis testing – Normal, t-, F- and Chisquare; Steps in tests of significance –large sample tests-Z tests for Means and Proportions, Small sample tests –t-test for Means, F test for Equality of Variances, Chi-square test for independence of Attributes.

Modelling and Forecasting Methods: Concept of Linear and Non-Liner Forecasting model, Concepts of Trend, Exponential Smoothing, Linear and Compound Growth model, Fitting of Logistic curve and their Applications, Moving Averages, Forecasting accuracy tests.

Part III: General Civil Engineering (For All Specializations Except Applied Geology - 20 Marks)

Mechanics and Strength of Materials: System of forces, free-body diagrams, equilibrium equations, center of gravity, bending moment and shear force in statically determinate beams, simple stress and strain relationships, simple bending theory, flexural and shear stresses, torsion and buckling of columns.

Construction Materials and Management: Construction materials: Structural steel – composition, material properties and behavior; Concrete - constituents, mix design, short-term and long-term properties. Construction Management: Types of construction projects; Project planning and network analysis - PERT and CPM. Cost estimation.

Soil Mechanics: Three-phase system and phase relationships, index properties; Unified and Indian standard soil classification system; Permeability - one dimensional flow, Seepage through soils – two dimensional flow, flow nets, uplift pressure, piping, capillarity, seepage force; Principle of effective stress and quicksand condition; Compaction of soils; One- dimensional consolidation, time rate of consolidation; Shear Strength, Mohr's circle, effective and total shear strength parameters.

Fluid Mechanics: Properties of fluids, fluid statics; Continuity, momentum and energy equations and their applications; Potential flow, Laminar and turbulent flow; Flow in pipes, pipe networks; Concept of boundary layer and its growth; Concept of lift and drag.

Hydrology: Hydrologic cycle, precipitation, evaporation, evapo-transpiration, watershed, infiltration, unit hydrographs, hydrograph analysis, reservoir capacity, flood estimation and routing, surface runoff models, ground water hydrology - steady state well hydraulics and aquifers; Application of Darcy's Law.

Irrigation: Types of irrigation systems and methods; Crop water requirements - Duty, delta, evapotranspiration; Gravity Dams and Spillways; Lined and unlined canals, Design of weirs on permeable foundation; cross drainage structures.

Transportation Infrastructure: Geometric design of highways - cross-sectional elements, sight distances, horizontal and vertical alignments.

Highway Pavements: Highway materials - desirable properties and tests; Desirable properties of bituminous paving mixes; Design factors for flexible and rigid pavements; Design of flexible and rigid pavement using IRC codes

Water and Wastewater Quality and Treatment: Basics of water quality standards – physical, chemical and biological parameters; Unit processes and operations; Water

requirement; Water distribution system; Drinking water treatment. Sewerage system design, quantity of domestic wastewater, primary and secondary treatment. Effluent discharge standards.

Air Pollution: Types of pollutants, their sources and impacts, air pollution control, air quality, standards.

Municipal Solid Waste: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).

Principles of Surveying: Errors and their adjustment; Maps - scale, coordinate system; Distance and angle measurement - Levelling and trigonometric levelling; Traversing and triangulation survey; Total station; Horizontal and vertical curves.

Part III: General Geology (For Applied Geology Specialization - 20 Marks)

Basic structural geology - stress, strain and material response; brittle and ductile deformation;
nomenclature and classification of folds and faults.

Petrology of common igneous, sedimentary and metamorphic rocks.

Geological time scale; Geochronology and absolute time. Stratigraphic principles; major
stratigraphic divisions of India.
Mineral, coal and petroleum resources of India.

Engineering properties of rocks and soils. Weathering and soil formation; landforms created by river, wind, glacier, ocean and volcanoes.

Crystallography – basic crystal symmetry and concept of point groups. Mineralogy – silicate crystal
structure and determinative mineralogy of common rock forming minerals.

Section B- Syllabus for Different Specializations Candidates in Civil Engineering

Total Marks: 60

I- Structural Engineering

Structural Analysis (20 Marks): Analysis of statically determinate and indeterminate structures (trusses, beams and frames) by force and displacement methods; Analysis using matrix Stiffness and matrix flexibility methods of structural analysis, direct stiffness methods.

Concrete Structures (20 Marks): Limit state design concepts; Design of beams, slabs, columns, foundations.

Steel Structures (20 Marks): Limit state design concepts; Design of tension, compression members and beams; Simple connection design – welded, bolted.

II- Transportation Engineering

Transportation Planning (20 Marks)

Trip Generation Analysis: Trip Generation Models- Zonal Models, Category analysis, Household Models, Trip Attractions of Work Centres & Commercial Trips.

Trip Distribution Analysis: Trip End and Trip Interchange Models; Trip Distribution Models - Growth Factor Models, Gravity Models, Opportunity Models and their calibration.

Mode Split and Route Split analysis: Mode Split Analysis- Mode Choice Behaviour, Competing Modes, Mode Split Curves, Probabilistic Models and Two Stage Mode Split Analysis; Route Split Analysis.

Elements of Transportation Networks, Coding, Minimum Path Tress, Diversion Curves, All-or-Nothing Assignment, Capacity Restrained Assignment, Multipath Assignment.

Traffic Engineering (20 Marks)

Components of Road Traffic – Vehicle, Driver and Road; Road User and Vehicle Characteristics and their effect on Road Traffic; Traffic Manoeuvres. Traffic Stream Characteristics, Relationship between Speed, Flow and Density. Use of Counting, Interval and Translated Distributions for Describing Vehicle Arrivals, Headways, Speeds, Gaps and Lags; Fitting of Distributions, Goodness of Fit Tests.

Traffic Engineering Studies and Analysis: Sampling in Traffic Studies, Adequacy of Sample Size; Objectives, Methods of Study, Equipment, Data Collection, Analysis and Interpretation (including Case Studies) of (a) Speed (b) Speed and Delay (c) Volume (d) Origin and Destination (e) Parking (f) Accident & other Studies.

Highway Capacity & Level-of-Service Studies: Concepts, Factors Affecting Capacity & Level-Of Service, Capacity Analysis of Different Highway Facilities, Passenger Car Units, Problems in Mixed Traffic Flow.

Pavement Materials and Design (20 Marks)

Pavement Materials: Types and Component parts of Pavements - A brief study on aggregates, bitumen and modified bitumen like cutback, emulsion, polymer modified bitumen - Bituminous mix design methods, specifications and testing.

Analysis & Design of Flexible Pavement: Stresses and Deflections in Homogeneous Masses - Burmister's 2- layer, 3- layer Theories - Wheel Load Stresses - ESWL of Multiple Wheels - ESAL – VDF - Repeated Loads and EWL factors - Sustained Loads and Pavement behaviour under Traffic Loads - Empirical, Semi-empirical, Analytical and Mechanistic-empirical approaches - Development, Principle, Design steps, Advantages and Applications of different Pavement Design Methods – Mechanistic Empirical Pavement Design – Guidelines and example.

Analysis & Design of Rigid pavements: Types of Stresses and Causes, Factors influencing the Stresses; General conditions in Rigid Pavement Analysis, ESWL, Wheel Load Stresses, Warping Stresses, Friction Stresses, Combined Stresses - Types of Joints in Cement Concrete Pavements and their Functions, Joint Spacing, Design of Slab Thickness, Design of Joint Details for Longitudinal Joints, Contraction Joints and Expansion Joints, IRC Method of Design - – Mechanistic Empirical Pavement Design.

III- Offshore, Coastal and Ocean Engineering

Water Wave Mechanics (20 marks)

Small Amplitude wave theory and applications, Shallow water wave transformation, Finite Amplitude waves, Random waves, Wave forces- Morison Equation

Coastal and Harbour Engineering (20 marks)

Coastal erosion, Sediment transport, Coastal protection structures- Seawalls, Groins, offshore-Breakwaters and Artificial beach nourishment.

Classification of berthing structures, loads on berthing structures, Classification of Breakwaters, Analysis and design of Rubble mound breakwater, classification of harbours and alignment of breakwaters.

Ship Hydrodynamics and Offshore Structures (20 marks)

Classification of offshore structures, materials and construction of jacket and gravity platforms, design methods and Code provisions, wave forces on offshore structure.

Ship particulars, coefficients of form, transverse stability, inclining experiment, longitudinal stability of the ship.

IV- Geotechnical Engineering

Fundamentals of soil behavior (20 marks)
Clay mineralogy, clay-water electrolytes, soil fabric and structure, effective stress principle and affecting factors, permeability, consolidation properties of soils in one- and three-dimensional directions, testing and evaluation of consolidation parameters, direct and triaxial shear tests, determination of shear strength parameters in granular and fine grained soils, Tests based on drainage conditions i.e. UU, CU, and CD tests, total and effective shear strength parameters, modified failure envelope and stress path, types of stress paths, pore pressure parameters, factors affecting shear strength, slope stability, earth pressure theory and design of retaining structures.

Ground improvement and soil reinforcement (20 Marks)
Vibro and dynamic compaction methods, column stabilisation of soils, chemical and jet grouting process, soil fracturing techniques, types and functions of various geotextiles, testing and evaluations of geotextiles properties with and without soil reinforcement, mechanism and principles of soil reinforcement, bearing capacity improvement, geosynthetics in road pavements and environmental control.

Foundation Engineering (20 Marks)
Soil exploration – sampling, field tests, SPT corrections, geophysical exploration, shallow and deep foundations – bearing capacity and settlement
Raft foundations: Bearing capacity equations - Design considerations – Conventional design procedure for rigid mat - Uplift pressures - Methods of resisting uplift -Floating foundations. **Pile foundations:** Uses of piles - Classification of piles based on purpose and material - Determination of type and length of piles - Determination of bearing capacity of axially loaded single vertical pile - (static and dynamic formulae) - Determination of bearing capacity by penetration tests and pile load tests (IS methods) - Negative skin friction - Group action and pile spacing - Analysis of pile groups - Load distribution by Culmann's method.

V- Environmental Engineering

Module 1 Water and Wastewater Engineering (20 Marks)

Water and Waste water characteristics- (Physical, Chemical and biological)-waste water composition, Fundamentals of process analysis of different reactors-Reactions and reaction kinetics

Water demands- estimation of demands, design of water treatment plant for surface and ground water, distribution of water supply system

Wastewater collection system, design of physio-chemical and biological wastewater system-sewage and industrial wastewater, tertiary wastewater treatment, advanced wastewater treatment, treatment of sludge from wastewater plant.

Module 2 Air Pollution and Control (20 Marks)

Sources, Classification, Causes and effects of air pollution, Air Quality Standards, Meteorology and its effect on Air pollution, Dispersion modelling, Air pollution sampling and Analysis, Monitoring instrumentation and principles of operation, Control equipment for gaseous and particulate pollutants

Module 3 Miscellaneous topics (20 Marks)

Solid waste management- generation, composition, collection, processing, material recovery, landfills, incineration, composting

Management of special waste- hazardous, biomedical, construction and demolition, E-waste

Environmental Impact Assessment- screening, scoping, impact prediction, mitigation, public participation

VI- Water Resources Engineering

Fluid Mechanics and Hydraulics (20 Marks)

Fluid Mechanics: Properties of fluids, fluid statics; Continuity, momentum and energy equations and their applications; Potential flow, Laminar and turbulent flow; Flow in pipes, pipe networks; Concept of boundary layer and its growth; Concept of lift and drag.

Hydraulics: Forces on immersed bodies; Flow measurement in channels and pipes; Dimensional analysis and hydraulic similitude; Channel Hydraulics - Energy-depth relationships, specific energy, critical flow, hydraulic jump, uniform flow, gradually varied flow and water surface profiles.

Surface Water Hydrology and Hydrologic Systems (20 Marks)

Hydrologic Processes – Precipitation, Infiltration, Evaporation and Transpiration, Hydrograph analysis – Baseflow separation, Separation of losses and rainfall excess, Introduction to unit hydrograph, Flood routing – Hydrologic and hydraulic routing, Hydrologic simulation models – steps in watershed modelling.

Concept of System and Systems Analysis, Systems Techniques in Water Resources – optimization of functions of single and multiple variables using calculus.

Discrete Probability Distributions of Hydrologic Random Variables, Continuous Probability Distributions of Hydrologic Random Variables – general and standard normal distributions, central limit theorem.

Groundwater Hydrology, GIS and Remote Sensing Concepts (20 Marks)

Governing equations for groundwater flow - Steady State and transient flow, Transport of contaminants in groundwater - processes, governing equations, Application of finite difference method to saturated and unsaturated flow.

Concepts and foundations of remote sensing- Energy sources and radiation principles- Energy interactions in the atmosphere – Energy interaction with earth surface features - Spectral reflectance of vegetation, soil and water - Atmospheric influence on spectral response patterns, GIS - Definition, Spatial and attribute data, Components of GIS, DBMS – Geospatial data representation (Raster, Vector).

VII- Building Materials and Construction Management

Syllabus for the specialization: Building Technology

Concrete Technology (20 Marks)
Production of cement and concrete materials – Chemistry and hydration of cement and mineral admixtures – Chemical admixtures – Fresh, hardened, and durability properties – Concrete mix design and proportioning – Properties of aggregates, steel and other materials used in concrete – Methods of mixing, transporting, placing, compaction, curing – Sampling of materials – Acceptance criteria – Special concrete's: fibre reinforced concrete, self-consolidating concrete, light-weight concrete, heavy-weight concrete, geopolymer, alkali activated concrete, ultra-high performance concrete, ferrocement concrete, pervious concrete, lean concrete, polymer modified concrete, underwater concrete, shotcrete, recycled aggregate concrete, textile reinforced concrete, SIFCON, GFRP, LC3 and 3D printable cementitious systems, sulphur concrete, concrete canvas, translucent concrete.

Forensic Engineering and Rehabilitation of Structures (20 Marks)
Causes of distress in concrete structures – Deterioration mechanisms of construction materials and systems – Transport mechanisms of aggressive ions – Rebar corrosion – Effects due to climate, fire, chemicals, wear and erosion, earthquake – Types of

cracks – Systematic approach for diagnosis and assessment of distress – Non-Destructive Tests: ultrasonic pulse velocity method, rebound hammer technique, rebar locator, pull out tests, corrosion potential assessment, cover meter survey, resistivity measurement, core sampling and testing – Crack detection techniques – Tests to assess water, air, chlorides, carbon dioxide, pH – Repair materials: cement, polymer, epoxy, latex – Repair to active and dormant cracks and leakages – Repair, rehabilitation and retrofitting (active & passive) of various damaged structural elements (foundation, column, beam, slab, bridge components) and masonry – Underwater repair – Chemical and electrochemical method of corrosion control – Cathodic protection – Facets of maintenance, routine and preventive maintenance, pre and post monsoon maintenance.

Characterization of construction materials (20 Marks)
Mercury Intrusion Porosimetry – Thermogravimetric analysis (TGA, DTA, DSC) – Types of calorimetry – Microscopy (Optical, TEM, SEM) – Spectroscopic Techniques: XRD, EDAX, XRF, Raman, UV-Visible, Atomic Absorption, Atomic Emission, Inductively Coupled Plasma, NMR, OES Electrical Impedance – Ion Chromatography – Ultrasound / X-ray Tomography –– Sample preparation and interpretation of results for different characterization techniques.

Syllabus for the specialization: Construction Management:

Project Formulation and Appraisal (20 Marks)
Project – Concepts - Principles - Analysis of Risk – Different Methods – Selection of a Project and Risk Analysis in Practice - Cost Benefit Analysis – Private sector participation in Infrastructure Development Projects - BOT, BOLT, BOOT, Time Value of Money – Project Cash Flows - Project Finance – Sources of finance.

Construction Planning, Scheduling, and Control (20 Marks)
Basic Concepts in the Development of Construction Plans - Defining Work Tasks and Work Break down Levels – Defining Precedence Relationships among Activities – Estimating Activity Durations – Estimating Resource Requirements for Work Activities - Gantt / Bar Chart – Types of Network and Techniques – Introduction to Floats, Types of Floats, usage of Floats for Project Decisions - Critical Path Method (CPM) Network Analysis - PERT Network Modelling and Time Analysis - Crashing and Time/Cost Trade-offs – Computerization in Construction – BIM

Resource Management and Control in Construction (20 Marks)
Resource Planning, Characteristics of resources, - Manpower planning and forecasting – Resource utilization, measurement of actual resources required – Resource levelling, resource smoothening – Value Management.

VIII - Geomatics Engineering

Module I: Basic Geomatics (20 marks)

Land Surveying- Various Levels, Levelling methods, Compass, Theodolite and Total Station and their uses, Tachometer, Trigonometric levelling, Traversing, Triangulation and Trilateration.

Remote Sensing- Basic concept, Electromagnetic spectrum, Spectral signature, Resolutions- Spectral. Spatial, Temporal and Radiometric, Platforms and Sensors, Remote Sensing Data Products - PAN, Multispectral, Microwave, Thermal, Hyperspectral, Visual and digital interpretation methods

Module II: GNSS and Aerial Photogrammetry (20 marks)

GNSS- Principle used, Components of GNSS, Data collection methods, DGPS, Errors in observations and corrections.

Aerial Photogrammetry- Types of photographs, Flying height and scale, Relief (height) displacement, Stereoscopy, 3-D Model, Height determination using Parallax Bar, Digital Elevation Model (DEM), Slope.

Module III: GIS and Digital Image Processing (20 marks)

GIS- Introduction, Data Sources, Data Models and Data Structures, Algorithms, DBMS, Creation of Databases (spatial and non-spatial), Spatial analysis - Interpolation, Buffer, Overlay, Terrain Modeling and Network analysis.

Digital Image Processing: Digital image characteristics: image histogram and scattergram and their significance, Variance-Covariance matrix, Correlation matrix and their significance, Radiometric and Geometric Corrections, Image Enhancement – Contrast Enhancement: Linear and Non-linear methods, Image Segmentation and Classification.

IX - Applied Geology

Petrology (20 Marks)

Igneous Petrology – Classification, forms, textures and genesis of common igneous rocks; magmatic differentiation; binary and ternary phase diagrams; Metamorphic Petrology – Structures and textures of metamorphic rocks. Physico-chemical conditions of metamorphism and concept of metamorphic facies, grade and baric types; chemographic projections; metamorphism of pelitic, mafic and impure carbonate rocks; role of bulk composition including fluids in metamorphism; thermobarometry and metamorphic P-T-t paths, and their tectonic significance.

Economic Geology (20 Marks)

Ore-mineralogy; ore forming processes vis-à-vis ore-rock association (magmatic, hydrothermal, sedimentary, supergene and metamorphogenic ores); fluid inclusions as ore genetic tools. Coal and petroleum geology; marine mineral resources. Prospecting and exploration of economic mineral deposits - sampling, ore reserve estimation, geostatistics, mining methods. Ore dressing and mineral economics. Distribution of mineral, fossil and nuclear fuel deposits in India. Stratigraphy of peninsular and extra-peninsular India.

Engineering Geology (20 Marks)

Physico-mechanical properties of rocks and soils; rock index tests; Rock failure criteria (Mohr-Coulomb, Griffith and Hoek-Brown criteria); shear strength of rock discontinuities; rock mass classifications (RMR and Q Systems); in-situ stresses; rocks as construction materials; geological factors in the construction of engineering structures including dams, tunnels and excavation sites. Analysis of slope stability.

Note:
The syllabus for the Specialization Section for candidates with an interdisciplinary research area or a different UG/PG background may be framed separately by the Research Supervisor and the Departmental PhD Coordinator and forwarded to the Doctoral Committee of the research scholar for approval.