



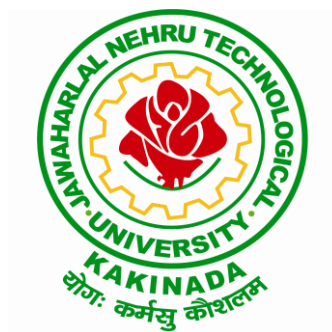
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
KAKINADA – 533 003, Andhra Pradesh, India

DEPARTMENT OF CIVIL ENGINEERING

COURSE STRUCTURE & SYLLABUS

M.Tech Highway Engineering Programme

(Applicable for batches admitted from 2019-2020)



JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA



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I - Semester

| S.No | Course No | Category | Course Name | L | T | P | C | Marks |
|------|-----------|-----------------|---|---|---|----|-----------|------------|
| 1 | MHEI-1 | Core1 | Highway Infrastructure Design | 3 | 0 | -- | 3 | 100 |
| 2 | MHEI-2 | Core2 | Advanced Traffic Engineering | 3 | 0 | -- | 3 | 100 |
| 3 | MHEI-3 | Elective I | a). Applied Statistics | | | | | |
| | | | b). Project Management | | | | | |
| | | | c). Bridge Engineering | | | | | |
| 4 | MHEI-4 | Elective II | a). Remote Sensing & Global Positioning Systems | | | | | |
| | | | b). Engineering of Ground | | | | | |
| | | | c). Advanced Concrete Technology | | | | | |
| 5 | MHEMC | | Research Methodology and IPR | 2 | 0 | 0 | 2 | 100 |
| 6 | MHEPI-1 | Lab 1 | Highway Engineering Lab | - | 0 | 4 | 2 | 100 |
| 7 | MHEPI-2 | Lab 2 | Bituminous Testing Lab | - | 0 | 4 | 2 | 100 |
| 8 | MHEA-1 | Audit Course –1 | | 2 | 0 | 0 | 0 | 100 |
| | | | Total Credits /Marks | | | | 18 | 800 |

II – Semester

| S.No. | Course No | Category | Course Name | L | P | C | Marks |
|-------|-----------|-----------------|---|----|----|-----------|------------|
| 1 | MHEII-1 | Core 3 | Pavement Analysis & Design | 3 | -- | 3 | 100 |
| 2 | MHEII-2 | Core 4 | Pavement Construction, Maintenance & Management | 3 | -- | 3 | 100 |
| 3 | MHEII-3 | Elective III | a). Highway Safety Engineering | | | | |
| | | | b). Land use and Transportation Modeling | | | | |
| | | | c). Transportation System Management | | | | |
| 4 | MHEII-4 | Elective IV | a). Environmental Impact Assessment for Transportation Projects | | | | |
| | | | b). GIS Applications in Transportation Engineering | | | | |
| | | | c). Highway Project Formulation and Economics | | | | |
| 5 | MHEPII-1 | Lab 3 | Advanced Highway Engineering Lab | -- | 4 | 2 | 100 |
| 6 | MHEPII-2 | Lab 4 | Transportation Simulation Lab | -- | 4 | 2 | 100 |
| 7 | MHEMP | Core | Mini Project with Seminar | 0 | 4 | 2 | 100 |
| 8 | MHEA-2 | Audit Course -2 | | 2 | 0 | 0 | 100 |
| | | | Total Credits /Marks | | | 18 | 800 |



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III - Semester

| S.No | Course No | Category | Course Name | L | T | P | C | Marks |
|-----------------------------|--------------|---------------|---|-----------|----|----|------------|-------|
| 1 | MHEIII-1 | Elective-V | | 3 | -- | -- | 3 | 100 |
| | | | a). Urban Transportation | | | | | |
| | | | b). Traffic Flow Analysis | | | | | |
| | | | c).Advanced Traffic Engineering | | | | | |
| 2 | MHEIII-2 | Open Elective | Open Elective /MOOCS | 3 | -- | -- | 3 | 100 |
| 3 | DISSERTATION | Core | DissertationPhase-I / Industrial Project (To be continued and Evaluated next Semester)* | -- | -- | 20 | 10 | |
| Total Credits /Marks | | | | 16 | | | 200 | |

*** Evaluated and displayed in 4th Semester marks list**

**** Students Going for Industrial Project / Thesis will complete these courses through MOOCS**

IV- Semester

| S. No. | Course No | Category | Course Name | L | T | P | C | Marks |
|-----------------------------|--------------|----------|---|---|---|----|-----------|------------|
| 1 | DISSERTATION | Core | Dissertation Phase II (Continued from III Semester) | 0 | 0 | 32 | 16 | 100 |
| Total Credits /Marks | | | | | | | 16 | 100 |

Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.



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| | | | | |
|--------------------------------------|----------|----------|----------|----------|
| I Year - I Semester | L | T | P | C |
| | 3 | 0 | 0 | 3 |
| HIGHWAY INFRASTRUCTURE DESIGN | | | | |

UNIT-I:

Highway Cross Section Elements and Geometric Design Of Highways: Functional Classification of Highway System; Design Controls – Topography, Driver characteristics, Vehicle Characteristics, Traffic, Capacity and Level of Service, Design Speed. Objectives of Geometric Design. Carriageway, Shoulders, Formation, Right of way; Kerbs, foot paths, Medians- design specifications; Pavement Surface characteristics – Skid Resistance, factors affecting Skid resistance, Measurement of Skid Resistance; Road Roughness, measurement of Road roughness; Camber, Objectives of Camber, design standards.

UNIT-II:

Horizontal and Vertical Alignment: Objectives of horizontal curves; Super elevation – Need for Super elevation; Method of computing super elevation; Minimum Radius of Curve; Methods of attainment of super elevation; Extra widening on Curves; Transition Curves – Objectives and Design. Gradients – Types of Gradients, Design Standards; Vertical Curves – Summit Curves, Valley Curves and Design criteria for Vertical Curves; Combination of Vertical and Horizontal Curves – Grade Compensation; Sight Distances – Stopping Sight Distance, Overtaking Sight Distance and Intermediate Sight Distance; Importance of Sight Distances for Horizontal and Vertical Curves.

UNIT-III:

Intersection Design: Types of Intersections; Design Principles for Intersections; Design of At-grade Intersections – Channelisation, Objectives; Traffic Islands and Design standards; Rotary Intersection – Concept and Design, Advantages and Disadvantages; Grade separated Interchanges – Types, warrants and Design standards.

UNIT-IV:

Traffic Signs and Road Markings : Types of Road Signs; Guidelines for the provision of Road Signs; Cautionary Signs, Regulatory Signs, Information Signs – Design standards; Road markings – Objectives of Road Markings; Types of Road Markings; Role of Road markings in Road Safety and Traffic Regulation; Specification for Road Markings. Highway Appurtenances – Delineators, Traffic Impact Attenuators, Safety Barriers.

UNIT-V:

Miscellaneous Elements: Requirements of Pedestrians; Pedestrian facilities on Urban Roads; Cycle Tracks – Guidelines and Design standards; Bus bays – Types and Guide lines; Design of On-street and Off street Parking facilities – Guidelines for lay out Design.



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REFERENCES:

1. Principles and Practice of Highway Engineering, L.R.Kadiyali and N.B.Lal, Khanna Publications
2. Traffic Engineering and Transportation Planning, L.R.Kadiyali, Khanna Publications
3. Highway Engineering, C.E.G.Justo and S.K.Khanna, Nem Chand and Brothers.
4. IRC Codes for Signs, Markings and Mixed Traffic Control in Urban Areas.



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| I Year - I Semester | | L | T | P | C |
|------------------------------|--|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Advanced Traffic engineering | | | | | |

UNIT-I

Basic Aspects of Traffic Engineering Aim of traffic engineering, traffic stream components and characteristics, road user characteristics, vehicle characteristics, acceleration characteristics, measures of quality, measures of separation, relationship among traffic parameters and empirical relationships, mechanics of traffic flow, macroscopic approach, microscopic-approach and human factors approach, discrete distributions, binomial distribution, Poisson's distribution, exponential distribution, exponential distribution, normal distribution.

UNIT-II

Traffic Studies, Measurement and Analysis; Volume studies, speed studies, travel forecasting principles and techniques, design hourly volumes and speed, origin and destination studies, presentation of data and analysis, testing of hypothesis relating to improvements.

UNIT-III

Travel Time amid Delay Studies; Various uses, travel time and delay studies, various methods, data collection and analysis, density studies and headways, gap acceptance studies, intersection delay studies, traffic flow theory, queuing theory and simulation models.

UNIT-IV

Capacity Analysis of Traffic Facilities; Uninterrupted facilities, interrupted facilities, Level of Service, quality of service as per HCM, factors affecting LOS, computation of capacity and LOS, Measure of effectiveness, highway capacity and performance characteristics, intersection design.

UNIT-V

Traffic Control, Design and Regulation; Traffic signals, types, principles of phasing, tune diagram, signalized intersection, saturation flow, saturation headway, capacity of lane group, concept of critical lane group, signal timing, phase plan, phase diagram, splitting of phase, clearance interval, pedestrian requirement, guidelines for protected movements, signal co-ordination, emerging themes, inter-modalism, access management, congestion management, environmental impact assessment.



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Suggested Reading

1. Introduction to Traffic Engineering, R. Srinivasa Kumar, Universities Press, 2018.
2. Highway Capacity Manual, Transportation Research Board, National Research Council, Washington, D.C., 2010.
3. Daganzo, C.R, Fundamentals of Transportation and Traffic Operations, Pergamon, Elsevier Science Inc., New York, 1997.
4. Salter, R.J., Traffic Engineering: Worked Examples, Macmillan, London, 1989.
5. Pignataro, L.J., Traffic Engineering: Theory and Practice, Prentice Hall, Englewood Cliffs, 1973.
6. Wohl, M. and Martin, B.V, Traffic System Analysis for Engineers and Planners, McGraw Hill, New York, 1983.
7. Drew, D.R., Traffic Flow Theory, McGraw Hill, New York, 1964.



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| I Year - I Semester | L | T | P | C |
|---------------------|---|---|---|---|
| | 3 | 0 | 0 | 3 |
| Applied Statistics | | | | |

UNIT-I:

Introduction & Sampling Techniques: Frequency distribution; Mean; Standard deviation; Standard error, Skewness; Kurtosis; Definitions and Applications; Simple random sampling; Stratified sampling; Systematic sampling; Sample Size determination; Applications in Traffic Engineering.

UNIT-II:

Statistical Distributions and Probability : Binomial, Poisson, Exponential and Normal distributions; Fitting of distributions; Mean and variance; Chi-square test of goodness-of-fit; Applications in Traffic Engineering. Probability - Laws of Probability; Conditional probability and Independent events; Laws of expectation.

UNIT-III:

Regression And Correlation: Linear regression and correlation; Multiple correlation; Multiple correlation coefficient; Standard error of estimate; Analysis of Variance; Curvilinear regression; Applications in Transportation Engineering.

UNIT-IV:

Multi Variate Data Analysis and Exact Sampling Distributions : Types of data; Basic vectors and matrices; Simple estimate of centroid, Standard deviation, Dispersion, Variance and covariance; Correlation matrices; Principal component analysis; Time series analysis. Exact Sampling Distributions - Chi-square distribution; Students T-distribution; Snedecor's F-distribution.

UNIT-V:

Tests Of Significance & Confidence Interval – I & II: Large sample and small sample tests; Tests for single mean, Means of two samples, Proportions, two variances, two observed correlation coefficients, paired T-tests, Applications. Tests Of Significance & Confidence Interval

– II -Intervals for mean, variance and regression coefficients; Applications in Traffic Engineering problems.

REFERENCES:

1. Basic Statistics - Simpson and Kafks; Oxford and IBH Calcutta, 1969.
2. Fundamentals of Mathematical Statistics – Gupta, S.C and Kapoor, K.V.Sultanchand.
3. Multivariate Data Analysis – Cootey W.W & Cohens P.R; John Wiley & Sons.



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| I Year - I Semester | | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| Project Management | | | | | |

UNIT-I

Introduction to Project Management: A systems Approach, Systems Theory and Concepts, Organisation, Management Functions, Overview of Management Objectives, Tools and Techniques, Project Management – Processes and Organisational Structures – Team Management – Project Manager as a Team Leader – Leadership Qualities, PMIS.

UNIT-II

Construction Cost and Value Engineering: Types of Estimates, Implementation of Cost Controls, Project Cost Forecasting, Cost Optimisation and Resources Planning - Value Engineering, Techniques for Project Selection, Break-Even Analysis, Cost Modelling, Energy Modelling, Life Cycle Cost Approach.

UNIT-III

Contract Management Safety in Construction Industry : Tendering and Contracting, Laws of Contracts, subcontracts, Potential Problems, Post Contract Problems, Documents, Conditions, Arbitration, Special Features of International Contracts. Quality Management and Safety in Construction Industry - Quality control by statistical methods, sampling plan, control charts, ISO 14000, Safety Measures, Safety Programmes, Safety Awareness and Implementation of Safety Plan – Compensation.

UNIT-IV

Project Scheduling and Analysis Methods : CPM, PERT, Linear programming, queuing concept, simulation, bidding models, game theory.

UNIT-V

Human Resource Management and Construction Management Practices : Man Power Planning – Training – Motivation – Industrial Relations – Welfare Measures – MIS – Components and Structure – Personal Management. Resource Management and Inventory - Basic concepts, labour requirements & productivity, non-productive activities, site productivity, equipment and material management, inventory control. Construction Management Practices - Implementation of Procedures and Practices – International Experiences– Case Studies – Examples.

REFERENCES:

1. Herold Kerzner - Project Management - A systems approach to Planning, Scheduling and Controlling. CBS Publishers and Distributors.
2. K. Waker A Teraih and Jose M. Grevan; Fundamentals of Construction Management and Organisations.
3. Anghel Patterson - Construction Cost Engineering Handbook - Marcel Dekken Inc.
4. Dell Isola - Value Engineering in Construction Industry, Van Nostrand Reinhold Co.,
5. Choudhary, S. Project Management, Tata McGraw Hill Publishing Co., Ltd.,
6. Raina UK, Construction management Practices, Tata McGrawhill Publishing Company Ltd.
7. Sengupta B and Guha H, Construction Management and Planning, Tata McGraw-Hill Publishing Company Limited, New Delhi.



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| I Year - I Semester | | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| Bridge Engineering | | | | | |

UNIT-I

Masonry arch Bridge design details- Rise, radius, and thickness of arch- Arch ring- Dimensioning of sub structures- Abutments pier and end connections.(Ref: IRC- SP-13)

UNIT-II

Super Structure: Slab bridge- Wheel load on slab- effective width method- slabs supported on two edges- cantilever slabs- dispersion length- Design of interior panel of slab- Pigeaud's method- design of longitudinal girders- Guyon-Messonet method- Hendry Jaegar method- Courbon's theory. (Ref: IRC-21), voided slabs, T-Beam bridges.

UNIT-III

Plate girder bridges- Elements of plate girder and their design-web-flange- intermediate stiffener- vertical stiffeners- bearing stiffener-design problem

UNIT-IV

Composite bridges- Composite action- shear connectors- composite or transformed section- design problem. (Ref: IRC:Section-VI)

UNIT-V

Sub structure- Abutments- Stability analysis of abutments- piers- loads on piers – Analysis of piers- Design problem(Ref: IRC-13, IRC-21, IRC-78)- Pipe culvert- Flow pattern in pipe culvers- culvert alignment- culvert entrance structure- Hydraulic design and structural design of pipe culverts- reinforcements in pipes .(Ref: IRC: SP-13)

REFERENCES:

1. Design of concrete bridges- Aswini, Vazirani, Ratwani
2. Essentials of bridge engineering- Jhonson Victor D

Design of bridges- Krishna Raju



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| I Year - I Semester | | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| Remote Sensing & Global Positioning Systems | | | | | |

UNIT-I:

Remote Sensing Technology :Basic Principles – Introduction , Electromagnetic and its properties, interaction with Earth surface materials, recent developments in Remote sensing, Social and legal implications of Remote Sensing, status of Remote Sensing. - Remote Sensing Platforms & Sensors - Introduction, Characteristics of imaging remote sensing instruments, satellite remote sensing system – a brief over view , other remote sensing satellites.

UNIT-II:

Pre-Processing and Enhancement Techniques for Remotely Sensed Data: Introduction,cosmetic operation; Geometric connection and registration, atmospheric correction. Enhancement Technique - Introduction, human visual system, contrast enhancement; Pseudo color enhancement.

UNIT-III:

Image Transforms: Introduction, arithmetic operations, empirically based image transforms,Principal component analysis , Multiple discriminant analysis etc.

UNIT-IV:

Filtering Technique Classification: Low-pass (smoothing filters) High pass (sharpening) filters,edge detection, frequency domain filters, geometrical basis, classification, Unsupervised and supervised classification, classification accuracy.

UNIT-V:

G.P.S.: Introduction, Elements of satellite surveying, e global positioning system, GPS satellites,Adjustment computations, GPS observables, Application of GPS technology in Highway alignment, Network planning.

REFERENCES:

- 1.GPS Satellite Surveys, Alfred Leick , Willey & Sons
2. Principles of Remote Sensing , Paul Jumani, ELBS , 1985.
3. Computer Processing of Remotely sensed Images An Introduction – Paul M.Mather, John Wiley & Sons 1989.



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| I Year - I Semester | L | T | P | C |
| | 3 | 0 | 0 | 3 |
| Engineering of Ground | | | | |

UNIT-I:

Introduction to Engineering Ground Modification: Need and objectives, Identification of soil types, In situ and laboratory tests to characterise problematic soils; Mechanical, Hydraulic, Physico-chemical, Electrical, Thermal methods, and their applications.

UNIT-II:

Mechanical Modification – Deep Compaction Techniques- Blasting Vibrocompaction, Dynamic Tamping and Compaction piles.

UNIT-III:

Hydraulic Modification – Objectives and techniques, traditional dewatering methods and their choice, Design of dewatering system, Electro-osmosis, Electro-kinetic dewatering.

Filtration, Drainage and Seepage control with Geosynthetics, Preloading and vertical drains,

UNIT-IV:

Physical and Chemical Modification – Modification by admixtures, Shotcreting and Guniting Technology, Modification at depth by grouting, Crack Grouting and compaction grouting, Jet grouting, Thermal Modification, Ground freezing.

UNIT-V:

Modification by Inclusions and Confinement - Soil reinforcement, reinforcement with strip, and grid reinforced soil. In-situ ground reinforcement, ground anchors, rock bolting and soil nailing.

Text Books

1. Hausmann, M. R. (1990) – Engineering Principles of Ground Modifications, McGraw Hill publications
2. M. P. Moseley and K. Krisch (2006) – Ground Improvement, II Edition, Taylor and Francis

References:

1. Koerner, R. M (1994) – Designing with Geosynthetics – Prentice Hall, New Jersey
2. Jones C. J. F. P. (1985) – Earth Reinforcement and soil structures – Butterworths, London.
3. Xianthakos, Abreimson and Bruce - Ground Control and Improvement
4. K. Krisch & F. Krisch (2010) - Ground Improvement by Deep Vibratory Methods, Spon Press, Taylor and Francis
5. Donald P Coduto – Foundation Design Principles and Practices, 2nd edition, Pearson, Indian edition, 2012.



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|------------------------------|--|----------|----------|----------|----------|
| I Year - I Semester | | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| Advanced Concrete Technology | | | | | |

UNIT-I:

Cement and Admixtures : Portland cement - chemical composition – Bogue's compounds - hydration - structure of hydrated cement - mechanical strength of cement gel - water held in hydrated cement paste - heat of hydration of cement - influence of compound composition on properties of cement - different types of cements. Admixtures - Classification – Mineral and chemical admixtures - Classification of mineral admixtures – properties – dosage - uses – Chemical admixtures – classification – properties – uses – High range water reducing agents – effect of dosage – multiple dosage of admixtures and their effects – effects of admixtures in RMC.

UNIT-II:

Aggregates: Classifications of aggregates - particle shape and texture - bond, strength and other mechanical properties of aggregate - specific gravity, bulk density, porosity, absorption and moisture content of aggregate - bulking of sand - deleterious substance in aggregate - soundness of aggregate - alkali-aggregate reaction - thermal properties - sieve analysis - fineness modulus - grading curves - grading of fine and coarse aggregates - gap graded aggregate - maximum aggregate size – combined a grading – BIS grading.

UNIT-III:

Fresh Concrete and Hardened Concrete: workability - factors affecting workability - measurement of workability by different tests - effect of time and temperature on workability - segregation and bleeding - Mixing of concrete - different types of mixing – vibration of concrete – revibration – setting times of fresh concrete – steps in manufacture of concrete – quality of mixing water. Hardened Concrete - water/cement ratio - Abram's law – Gel space ratio Maturity concept - effective water in mix - nature of strength of concrete - strength in tension and compression - Griffith's hypothesis - autogenous healing - curing of concrete - influence of temperature on strength - steam curing - testing of hardened concrete – relation between compressive and tensile strength - factors affecting strength - non-destructive testing methods. Durability of concrete - codal provisions.

UNIT-IV:

Elasticity, Shrinkage and Creep: Modulus of elasticity – static and dynamic modulus of elasticity - Poisson's ratio - early volume changes - swelling - shrinkage - mechanism of shrinkage - factors affecting shrinkage - differential shrinkage - moisture movement - creep of concrete - factors influencing creep - relation between creep and time - nature of creep - effects of creep in structural concrete – Codal provisions – Rheology of creep.



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UNIT-V:

Concrete Mix Design and Special Concrete Issues : factors in the choice of concrete mixproportions – statistical quality control – Acceptance criteria as per IS 456-2000 – various mix design methods for normal concrete – BIS method – Road note no.4 method, ACI method – High strength concrete mix design – durability aspects in concrete mix design as per IS 456-2000. Special Concrete - Light weight concrete – Light weight aggregates – Light weight concrete mix design – Cellular concrete – Fiber reinforced concrete – Different types of fibres – Factors affecting properties of F.R.C. – Applications – Polymer concrete – Types of polymer concrete – Properties of polymer concrete – Applications – High Performance Concrete -Self Compacting concrete – smart concrete.

TEXT BOOKS:

1. Properties of Concrete by A.M.Neville, ELBS publications.
Concrete Technology by M.S.Shetty, S.Chand& Co



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| I Year - I Semester | L | T | P | C |
|---------------------|---|---|---|---|
| | 3 | 0 | 0 | 3 |

Research Methodology and IPR

UNIT - I

Research methodology: Objectives and motivation of research - Types of research - Research approaches - Significance of research - Research methods versus methodology - Research and scientific method - Importance of research methodology - Research process - Criteria of good research - Problems encountered by researchers in India - Benefits to the society in general. Defining the research problem: Definition of research problem - Problem formulation - Necessity of defining the problem - Technique involved in defining a problem.

UNIT – II

Literature survey: Importance of literature survey - Sources of information - Assessment of quality of journals and articles - Information through internet.

Literature review: Need of review - Guidelines for review - Record of research review.

UNIT – III

Research design: Meaning of research design - Need of research design - Feature of a good design - Important concepts related to research design - Different research designs - Basic principles of experimental design - Developing a research plan - Design of experimental set-up - Use of standards and codes.

UNIT – IV

Data collection: Collection of primary data - Secondary data - Data organization - Methods of data grouping - Diagrammatic representation of data - Graphic representation of data - Sample design - Need for sampling - Some important sampling definitions - Estimation of population - Role of statistics for data analysis - Parametric vs. non parametric methods - Descriptive statistics - Measures of central tendency and dispersion - Hypothesis testing - Use of statistical softwares.

Data Analysis: Deterministic and random data - Uncertainty analysis - Tests for significance - Chi-square - Student's t-test - Regression modeling - Direct and interaction effects – ANOVA - F-test - Time series analysis - Autocorrelation and autoregressive modeling.

UNIT - V

Research report writing: Format of the research report – Synopsis – Dissertation - Thesis - Its differentiation – References – Bibliography – Webliography - Technical paper writing - Journal report writing - Making presentation - Use of visual aids.

Research proposal preparation: Writing a research proposal and research report - Writing research grant proposal.

References:

- 1.C.R Kothari, "Research Methodology, Methods & Technique", New Age International Publishers, New Delhi, 2004.
- 2.R. Ganesan, "Research Methodology for Engineers", MJP Publishers, Chennai, 2011.
- 3.RatanKhananabis and SuvasisSaha, "Research Methodology", Universities Press, Hyderabad, 2015.
- 4.Y.P. Agarwal, "Statistical Methods: Concepts, Application and Computation", Sterling Publishing Pvt. Ltd., New Delhi, 2004.
- 5.Vijay Upagade and AravindShende, "Research Methodology", S. Chand & Company Ltd., New Delhi, 2009.
- 6.G. Nageswara Rao, "Research Methodology and Quantitative methods", BS Publications, Hyderabad,2012.



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| I Year - I Semester | | L | T | P | C |
| | | 0 | 0 | 4 | 2 |
| Highway Engineering Lab | | | | | |

1. Aggregate tests. (Shape, soundness abrasions, impact & creasing)
2. Tests on sub grade soils.
3. Soil stabilization tests.
4. California Bearing Ratio Test
5. Soil Classification & Grain size analysis.
6. Standard procter test
7. Mini project based on field and laboratory studies and data collected.

Note: All tests as per IS, ASTM, AASHTO, TRL, IRC procedures/specifications and guidelines



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| I Year - I Semester | | L | T | P | C |
| | | 0 | 0 | 4 | 2 |
| Bituminous Testing Lab | | | | | |

1. Bitumen and Tar Tests as per IS code provisions.
2. Benkelman beam test
3. Stone Polishing Value test
4. International Roughness Index test
5. Mix design for Bituminous mixes
6. Falling Weight Deflectometer.
7. Mini project based on field and laboratory studies and data collected.

Note: All tests as per IS, ASTM, AASHTO, TRL, IRC procedures/specifications and guidelines