M. Tech. DEGREE

TRANSPORTATION ENGINEERING AND MANAGEMENT

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(2009 -2010)
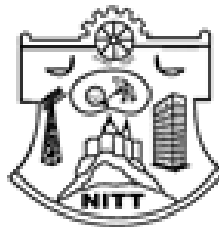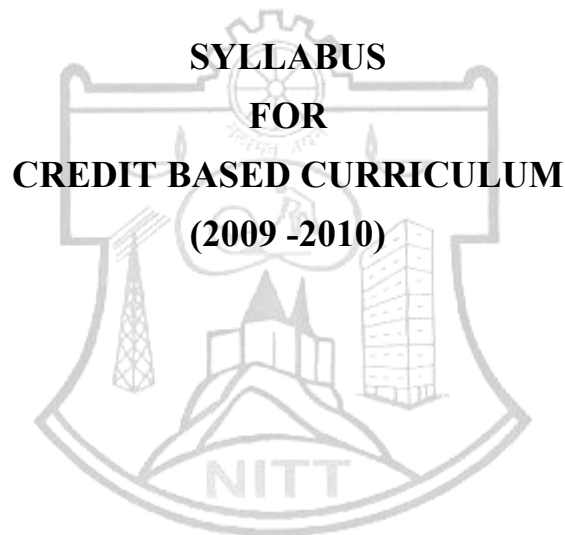
DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015, INDIA.

M. Tech. (TRANSPORTATION ENGINEERING AND MANAGEMENT)

The total minimum credits required for completing the M. Tech (Transportation Engineering and Management) Course is 64.

SEMESTER I

Code	Course of Study	L	T	P	C
MA601	Numerical Methods and Applied Statistics	3	0	0	3
CE601	Highway Traffic Analysis and Design	3	0	0	3
CE602	Pavement Analysis and Design	3	0	0	3
CE603	Transportation Systems	3	0	0	3
	Elective – I	3	0	0	3
	Elective – II	3	0	0	3
CE604	Traffic and Pavement Engineering Laboratory	0	0	3	2
		18	**0**	**3**	**20**

SEMESTER II

Code	Course of Study	L	T	P	C
CE605	Road Transport Management and Economics	3	0	0	3
CE606	Transportation Planning	3	0	0	3
CE607	Computer Simulation Applications in Transportation Engineering	3	0	0	3
	Elective – III	3	0	0	3
	Elective – IV	3	0	0	3
	Elective - V	3	0	0	3
CE608	CAD in Transportation Engineering	1	0	3	2
		19	**0**	**3**	**20**

SUMMER TERM

Practical Training (4 weeks)   -   -   -   -

SEMESTER III

Code	Course of Study	L	T	P	C
CE647	Project Work – Phase I	0	0	24	12

SEMESTER IV

Code	Course of Study	L	T	P	C
CE648	Project Work – Phase II	0	0	24	12

ELECTIVES (I Semester)

Code	Course of Study	L	T	P	C
CE611	Geographical Information Systems and Remote Sensing	3	0	0	3
CE612	Intelligent Transportation Systems	3	0	0	3
CE613	Pavement Materials	3	0	0	3
HM712	Human Resource Management	3	0	0	3
	Any other elective				

ELECTIVES (II Semester)

Code	Course of Study	L	T	P	C
CE614	Bridge Engineering	3	0	0	3
CE615	Theory of Traffic Flow	3	0	0	3
CE714	Environmental Impact Assessment	3	0	0	3
MB794	Project Management	3	0	0	3
	Any other elective				

Note: Student may also choose any other elective courses relevant to their degree with the consent of the course coordinator
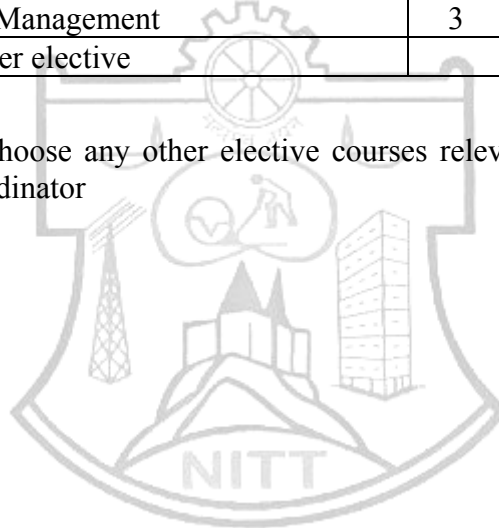
MA601 NUMERICAL METHODS AND APPLIED STATISTICS

Linear system – Gaussian elimination and Gauss – Jordan methods – matrix inversion – Gauss seidel method – Nonlinear equations – Regula falsi and Newton- Raphson methods – interpolation – Newton's and Lagrange's interpolation

Linear Programming – Graphical and Simplex methods – Measures of central tendency, dispersion, skewness and Kurtosis – Probability – conditional probability – Bayes' theorem

Random variable – two dimensional random variables – standard probability distributions – Binomial Poisson and normal distributions - moment generating function

Sampling distributions – confidence interval estimation of population parameters – testing of hypotheses – Large sample tests for mean and proportion – t-test, F-test and Chi-square test – curve fitting-method of least squares

Regression and correlation – rank correlation – multiple and partial correlation – analysis of variance-one way and two way classifications – experimental design – Latin square design – Time series analysis.

1. Bowker and Liberman, *Engineering Statistics,* Prentice-Hall, 1972.
2. Venkatraman, M.K., *Numerical Methods in Science and Engineering*, National Publisher Company.

CE601 HIGHWAY TRAFFIC ANALYSIS AND DESIGN

Elements of Traffic Engineering - road user, vehicle and road way. Vehicle characteristics - IRC standards - Design speed, volume. Highway capacity and levels of service - capacity of urban and rural roads - PCU concept and its limitations - Road user facilities - Parking facilities - Cycle tracks and cycleways - Pedestrian facilities.

Traffic volume studies, origin destination studies, speed studies, travel time and delay studies, Parking studies, Accident studies.

Elements of design - Alignment - Cross sectional elements - Stopping and passing sight distance. Horizontal curves - Vertical curves. Design problems – Hill Roads.

Traffic regulation and control - Signs and markings - Traffic System Management - Design of at-grade intersections – Principles of design – Channelisation - Design of rotaries - Traffic signals - pre-timed and traffic actuated. Design of signal setting - phase diagrams, timing diagram – Signal co-ordination.

Grade separated intersections - Geometric elements for divided and access controlled highways and expressways – Road furniture - Street lighting. Traffic Safety – Principles and Practices – Road Safety Audit.

1. ITE Hand Book, *Highway Engineering Hand Book*, Mc Graw - Hill.
2. AASHTO *A Policy on Geometric Design of Highway and Streets*
3. R. J. Salter and N. B. Hounsel, *Highway Traffic Analysis and Design*, Macmillan Press Ltd, 1996.

CE602 PAVEMENT ANALYSIS AND DESIGN

Introduction: Types and component parts of pavements, Factors affecting design and performance of pavements. Highway and airport pavements, functions of pavement components

Pavement Design Factors: Design wheel load, strength characteristics of pavement materials, climatic variations, traffic - load equivalence factors and equivalent wheel loads, aircraft loading, gear configuration and tyre pressure. Drainage – Estimation of flow, surface drainage, sub-surface drainage systems, design of sub-surface drainage structures

Flexible Pavement Design: Empirical, semi-empirical and theoretical approaches, design of highway and airport pavements by IRC, AASHTO Methods, applications of pavement design software

Rigid Pavement Design: Types of joints and their functions, joint spacing; design of CC pavement for roads, highways and airports as per IRC, AASHTO, design of joints. Design of continuously reinforced concrete pavements. Reliability; Use of software for rigid pavement design

Pavement Management: Pavement failures, maintenance of highways, structural and functional condition evaluation of pavements, pavement management system.

1. Yoder and Witczak, *Priniciples of Pavement Design*, John Wiley and Sons
2. Yang. H. Huang, *Pavement Analysis and Design*, Second Edition, Prentice Hall Inc.
3. Rajib B. Mallick and Tahar El-Korchi, *Pavement Engineering – Principles and Practice*, CRC Press (Taylor and Francis Group)
4. W.Ronald Hudson, Ralph Haas and Zeniswki , *Modern Pavement Management*, Mc Graw Hill and Co
5. Relevant IRC Codes

CE603 TRANSPORTATION SYSTEMS

Historical development of transport in India - 20 year Road Plans, National Transport Policy Recommendations, IRC, CRRI, Vision 2021, NHDP, PMGSY. Characteristics of different modes of transport and their integration and interactions - impact on environment.

Planning of railway - Passenger and goods terminals - layout - passenger facilities - traffic control.

Airport Planning, requirements and components. Design of runway and taxiway - Apron - parking configuration - terminal requirements - Airport marking and lighting - Air traffic control.

Planning of Harbours and ports - cargo handling - Containerization - Navigation aids - Inland waterways - Pipeline transportation.

Urban transportation systems - Mass rapid transit system - Light rail transit - Personal rapid

transit, guided way systems, cabin taxi, dual mode bus - Para transit systems - Demand responsive system - Intermediate public transport.

1. Paquette, R.J., et al, *Transportation Engineering Planning and Design,* John Wiley & Sons, New York, 1982.
2. Alan Black, *Urban Mass Transportation Planning*, McGraw-Hill, 1995.

CE604 TRAFFIC AND PAVEMENT ENGINEERING LABORATORY

Traffic Surveys: Volume count, Speed study, Parking study, Intersection turning movements, Speed and Delay study, Moving observer survey, Traffic noise measurement, Vehicle emission testing, Road lighting, User perception surveys, Road side and house hold interviews

Tests on sub grade soil, aggregates, bitumen, modified binders - Soil stabilization - Pavement evaluation.

Mix Design: Granular Sub-base, Bituminous – DBM, SDBC, BC, etc., Cement concrete.

Mini project report based on field and laboratory studies and data collected

CE605 ROAD TRANSPORT MANAGEMENT AND ECONOMICS

Motor Vehicles Act - statutory provision for road transport and connected organisations. Route scheduling, Freight transport, Vehicle scheduling, Optimum fleet size, Headway control strategies, Crew scheduling.

Depots and Terminals - Principles and types of layout, Depot location, Twin depot concept, Crew facilities. Design of parking facilities – Bus terminal, bus stops and bus bays

Transportation costs - Supply and demand - elasticity of demand; Supply of transport services - Economics of traffic congestion - Pricing policy. Vehicle operating costs - Fuel costs - Maintenance and spares - Depreciation - Crew costs - Value of travel time savings - Accident costs.

Economic analysis of projects - Methods of evaluation - Cost-benefit ratio, first year rate of return, net present value, and internal-rate of return methods; Indirect costs and benefits of transport projects.

Financing of road projects - methods – Private Public Partnership (PPP) - Toll collection - Economic viability of Build-Operate-Transfer Schemes – Risk Analysis - Case Studies.

1. Winfrey, *Economic analysis for Highways,* International Textbook Company, Pennsylvania, 1969.
2. CRRI, *Road User Cost Study in India*, New Delhi, 1982
3. IRC, *Manual on Economic Evaluation of Highway Projects in India*, SP30, 2007

CE606 TRANSPORTATION PLANNING

Urban Transportation Planning - Goals and objectives - Hierarchical levels of transportation planning - Forecast - Implementation - Constraints. UTP survey - Inventory of land use

Trip generation - Trip classification - productions and attractions - Multiple regression models - Category analysis - Trip production models - Trip distribution models - Linear programming approach.

Modal split models - Behavioural models - Probabilistic models - Utility functions - logit models - Two stage model. Traffic assignment - Assignment methods - Route-choice behaviour - Network analysis.

Landuse and its interaction - Lowry derivative models - Quick response techniques - Non-Transport solutions for transport problems. Characteristics of urban structure. Town planning concepts.

Preparation of alternative plans - Evaluation techniques - Plan implementation - Monitoring - Financing of Project – Case studies.

1. Hutchinson, B.G., *Principles of Urban Transport Systems Planning*, Scripta, McGraw-Hill, NewYork, 1974.
2. Khisty C.J., *Transportation Engineering - An Introduction*, Prentice Hall, India, 2002.

CE607 COMPUTER SIMULATION APPLICATIONS IN TRANSPORTATION ENGINEERING

Introduction to systems approach - Typical transportation systems - Mathematical models. Fundamentals of simulation - Monte Carlo method - Analog and digital simulation - Continuous and discrete models - Simulation languages - Introduction to CSMP.

Probability concepts - Random numbers - Pseudo random generators - Arrival patterns - Service time distributions, Queue discipline – Manual simulation of simple queuing system

Creating and moving transactions - Queues and facilities - Event scheduling - Internal logic of GPSS processor - Program control statements.

Priority - Preemption - Functions – Parameters and save values – Standard numerical attributes - Collection of statistics - Report preparation.

Applications of GPSS - Simple queuing problems - Inventory problems - Simulation of ports - Railway platforms and level crossings - Traffic signals. Analysis of simulation results - Model validation - Replication of random conditions - Time series analysis.

1. Gordon, G., *System Simulation,* Prentice-Hall of India, 1992
2. GPSS/PC, *User Manual, Minuteman Software,* USA, 1985

CE608 CAD IN TRANSPORTATION ENGINEERING

Transportation Software – Mx Road, REI heads, HDM4, TRIPS, MIGRAN
GIS and Remote Sensing Packages – ArcGIS, Geo-Concept,GRAM++, ENVI, ERDAS Imagine

Computer Aided Drafting - DBMS concepts - Civil Engineering Databases – Data entry & Reports. Spreadsheet concepts – Worksheet calculations in Civil Eng, - Regression & Matrix Inversion.

Development of C programs to solve problems using numerical techniques

    a. Roots of an equation using Newton – Raphson method.
    b. Solution of linear simultaneous equations using Gauss elimination.
    c. Matrix inversion using Gauss Jordan method
    d. Linear regression line of given points.

1. Rajaraman, V., *Computer Oriented Numerical Methods*, Prentice – Hall of India, 1995
2. Chapra S.C., and Canale R.P., *Numerical Methods for Engineers*, McGraw – Hill, 2004
3. Software Manuals

ELECTIVES (I Semester)

CE611 GEOGRAPHICAL INFORMATION SYSTEMS AND REMOTE SENSING

GIS Definition – Map and map analysis – Automated cartography – History and development of GIS – Hardware requirement – Type of data – Spatial and non- spatial data – Data structure – Vector and raster – Files and data formats – Data compression.

Spatial analysis – Data retrieval – Query – Overlay – Vector data analysis – Raster data analysis – Modelling in GIS – Digital Elevation Model – DTM – Types of output data – Output devices – Sources of errors – Types of errors – Elimination – Accuracies - The Global Positioning system and its applications.

Concepts and foundations of remote sensing - electromagnetic spectrum - EMR interaction with atmosphere, water vapour, ozone - Basic principles of photogrammetry – Spectral Signature and Spectral Signature curves - Remote sensing platforms and sensors.

Satellite system parameters, sensor parameters, earth resources and meteorological satellites, microwave sensors, Data Acquisition and interpretation - Visual Image Interpretation – Visual Image Interpretation Equipment - Digital Image Processing – Classification.

Applications in Survey, mapping and monitoring of land use/land cover - Transportation planning - Infrastructure development - Natural resources management - Urban Planning, Environment - Coastal Zone Management – Air Quality - Development of Resources Information Systems.

1. Burrough P.A. and Rachel A. McDonell, *Principles of Geographical Information Systems*, Oxford Publication, 2004.
2. C.P. Lo and Albert K. W. Yeung, *Concepts and Techniques of Geographical Information Systems*, Prentice-Hall India, 2006.
3. Thomas. M. Lillesand and Ralph. W. Kiefer, *Remote Sensing and Image Interpretation*, John Wiley and Sons, 2003.

CE612 INTELLIGENT TRANSPORTATION SYSTEMS

Introduction to Intelligent Transportation Systems (ITS) – Definition of ITS and Identification of ITS Objectives, Historical Background, Benefits of ITS - ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection.

Telecommunications in ITS – Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Vehicle – Road side communication – Vehicle Positioning System

ITS functional areas – Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS).

ITS User Needs and Services – Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management.

Automated Highway Systems - Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries.

1. ITS Hand Book 2000: *Recommendations for World Road Association (PIARC)* by Kan Paul Chen, John Miles.
2. Sussman, J. M., *Perspective on ITS*, Artech House Publishers, 2005.
3. National ITS Architecture Documentation, US Department of Transportation, 2007 (CD-ROM).

CE613 PAVEMENT MATERIALS

Subgrade soil - Soil composition and structure - Soil classification for engineering purposes - Origin, Classification, requirements, properties and tests on road aggregates

Origin, preparation, properties and tests, constitution of bituminous road binders, requirements - Bituminous Emulsions and Cutbacks: Preparation, characteristics, uses and tests

Bituminous Mixes: Mechanical properties - Resilient modulus, dynamic modulus and fatigue characteristics of bituminous mixes.

Weathering and Durability of Bituminous Materials and Mixes - Performance based Bitumen Specifications - Superpave mix design method

Cement Concrete for Pavement Construction: Requirements, design of mix for CC pavement, joint filler and sealer materials.

1. RRL, DSIR, *Bituminous Materials in Road Construction*, HMSO Publication, 1955
2. IS and IRC Publications on relevant topic.

CE614 GROUND IMPROVEMENT TECHNIQUES

Introduction: Engineering properties of soft – weak and compressible deposits – problems associated with weak deposit – Requirements of ground improvements – introduction to engineering ground modification, need and objectives.

Soil Stabilization: Science of soil stabilization – Mechanical modification – Hydraulic modification – Dewatering systems – Chemical modification – Modification by admixtures like lime, Cement, Bitumen etc. – Grouting – Deep jet mixing methods

Recent Ground improvement techniques: stabilization using industrial waste – modification by inclusion and confinement – soil nailing – stone column – compaction piles – dynamic compaction – prefabricated vertical drains – preloading – electro – osmosis – soil freezing vacuum consolidation – deep explosion – dry powdered polymers - enzymes

Soil reinforcement: Historical background, RCC – Vidalean concept of reinforced earth – Mechanisms – Types of reinforcements – Soil – Reinforcement – Interaction studies – Internal & External stability criteria – Design Principles of steep reinforced soil slops – pavements – Embankments on soft soils.

Geo-Synthetics: Geo-synthetic clay liner – Construction details – Geo Synthetic Materials – Functions – Property characterization – Testing Methods for Geo – Synthetics – Recent research and Developments. Control of Improvement – Field Instrumentation – design and analysis for bearing capacity and settlement of improved deposits.

1. Hausmann, M.R., *Engineering Principles of Ground Modification*, McGraw – Hill International Editions, 1990.
2. Purushotham Raj, *Ground Improvement Techniques*, Laxmi Publications, New Delhi
3. Sharma.S.K., Prinicples, *Practice and Design of Highway Engineering*, S.Chand & Co. New Delhi,1985.
4. Jones C. J. F. P, *Earth Reinforcement and Soil Structures*, Butterworths, London.

ELECTIVES (II Semester)

CE615 BRIDGE ENGINEERING

Components of Bridges – Classification – Importance of Bridges – Investigation for Bridges – Selection of Bridge site – Economical span – Location of piers and abutments – Subsoil exploration – Scour depth – Traffic projection – Choice of bridge type

Specification of road bridges – width of carriageway – loads to be considered – dead load – IRC standard live load – Impact effect

General design considerations – Design of culvert – Foot bridge - slab bridge – T-beam bridge – Pre-stressed concrete bridge – Box Culvert-Fly over bridges

Evaluation of sub structures – Pier and abutments caps – Design of pier – Abutments – Type of foundations

Importance of Bearings – Bearings for slab bridges – Bearings for girder bridges – Electrometric bearing – Joints – Expansion joints
Construction and Maintenance of bridges – Lessons from bridge failures

1. Ponnu swamy, s., *Bridge Engineering*, Tata McGraw - Hill, New Delhi, 1997
2. Victor, D.J., *Essentials of Bridge Engineering*, Oxford & IBH Publishers Co., New Delhi, 1980.
3. N. Rajagopalan, *BridgeSuperstructure*, Narosa Publishing House, New Delhi, 2006.

CE616 THEORY OF TRAFFIC FLOW

Traffic stream parameters - Fundamental diagram of volume-speed-density surface. Discrete and continuous probability distributions. Merging manoeuvres - critical gaps and their distribution.

Macroscopic models - Heat flow and fluid flow analogies - Shock waves and bottleneck control approach.

Microscopic models - Application of queuing theory - regular, random and Erlang arrival and service time distributions - Waiting time in single channel queues and extension to multiple channels.

Linear and non-linear car following models - Determination of car following variables - Acceleration noise.

Geographical Information System – Global Positioning System – Intelligent Transportation Systems - Area Traffic Control – Automatic Toll Collection – Smart Cards – Collision Detection System.

1. Drew, D.R., *Traffic Flow Theory and Control*, McGraw Hill., 1978.
2. TRB, *Traffic Flow Theory* - A Monograph, SR165, 1975.
3. Burrough P.A. and Rachel A. McDonell, *Principles of Geographical Information Systems*, Oxford Publication, 2004.

CE617 TRANSPORTATION NETWORK ANALYSIS AND OPTIMIZATION

Network flows: Applications, definitions, graphs, paths, trees, cycles, loops, walk, network representation (adjacency list and matrices) and basic network transformations; Network algorithms; Complexity, Search Algorithms, Strategies for designing polynomial algorithms.

Shortest Path Algorithms: Label setting, Dijkstra's and Dial's algorithms, Optimality conditions, label correcting algorithms and optimality conditions, detecting negative cycles,

all-pair shortest path algorithms; pre-flow push polynomial time algorithms, capacity scaling techniques.

Minimum cost network assignment: optimality conditions, cycle-canceling algorithm, Successive shortest path algorithm, other polynomial time variants; Network equilibrium analysis; principles and optimisation formulations, Frank-Wolfe algorithm; Special cases and variants.

Applications: Applications of min-cost, max-flow, and shortest path algorithms to transportation and infrastructure networks: transportation networks, airline, freight, facility location, logistics, network design, project scheduling, reliability of distribution systems, telecommunication/power networks etc.

Computer Software: Principles of TRIPS, SATURN, EMME/2, CUBE; Demo Versions, Case studies

1. Ahuja, R.., Magnanti, T.L., and Orlin, J.B., *Network Flows: Theory, Algorithms and Application,* Prentice Hall, New Jersey, 1993.
2. Bell, M.G., *Transportation Networks,* Elsevier Science Publishers, 1999.

CE618 ADVANCED HIGHWAY MATERIALS

Aggregate: Nature and properties – aggregate requirements – types and processing – aggregates for pavement base – aggregate for bituminous mixture – aggregate for Portland Cement Concrete – light weight aggregate – tests on aggregate – specification.

Bituminous Materials: conventional and modified binders – production – types and grade – physical and chemical properties and uses – types of asphalt pavement construction – principles of bituminous pavement construction – tests on bituminous materials. Bituminous Mix design – modified mixtures – temperature susceptibility and performance.

Cement /concrete based materials: Cement – properties – PCC mix design and properties – modified PCC – Mix Design – Behaviour – Performance – Tests on Cement and Concrete mixes. High Performance Concrete – low shrinkage – increased strength.

Composites, Plastics and Geosynthetics: Plastics and polymerization process – properties – durability and chemical composition – Reinforced Polymer Composites – Geosynthetics – Dry Powdered Polymers – Enzymes.

Reclamed/Recycled Waste Products: Reclaimed Materials – waste products in civil engineering applications – effect of waste products on materials, structure and properties – self healing and smart materials – locally available materials.

1. P. T. Sherwood, *Alternative Materials in Road Construction*, Thomas Telford Publication, London, 1997.
2. RRL, DSIR, *Soil Mechanics for Road Engineers,* HMSO, London , 1995
3. Koerner, R. M. *Designing with Geosynthetics,* Prentice Hall, Englewood Cliffs, New Jersey, U.S.A.
4. Shan Somayaji, *Civil Engineering Materials*, second edition, Prentice Hall Inc., 2001.